Stormwater: why waste it

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Glossary

AP Lands	Anangu Pitjantjatjara (Aust. Indigenous communities) Lands	
EEAT	Environment Engineering Association of Thailand	
LEK	local environmental knowledge; the local approach	
OTOP	One Tambon One Product	
PIS	public irrigation systems	เมืองไฟ
SEK	state/scientific environmental knowledge; the scientific approach	
SEARIN	Southeast Asian Rivers Information Network	
Tai	a language sub-group and an ethnic group	ไท
WSUD	water sensitive urban design	

As a child, while playing in gutters gushing with water, I would often ponder the foolishness of the water running down concrete drains, unused but for transporting plastic, cigarette butts and other rubbish, into the creek flowing behind our house. As teenager swimming in that creek, particularly near the stormwater outlet, was a murky affair. The impetus for this research stems from that same sense of childhood foolishness, reignited by seeing the changes brought to Bang Saen, Thailand, a town I have lived and studied in, by the introduction of stormwater infrastructure and concepts.

By critically examining the influence of the scientific environmental knowledge system, this thesis exposes the stormwater construct as a consequence of commodification and a desire for controlled water environments. Also suggested is stormwater's hypercommodification, as the scientific approach increasingly allows capitalist economic values to outweigh environmental and social values, in light of a perceived scarcity of water. This paper demonstrates how the socio-cultural values of the scientific approach have led to the stormwater construct. Local environmental approaches, such as those common in Thailand, are used to highlight the role of key values of the scientific approach on the stormwater construct.

Focusing specifically on overland flow, this research initially articulates those features and values of the scientific environmental knowledge system (SEK or the scientific approach) contributing to the stormwater construct. These findings are contrasted with the features and values common in local environmental knowledge systems (LEK or the local approach). This comparison allows the key elements of the scientific approach leading it to articulating aspects of overland flow as "stormwater" to be critically identified. The two knowledge systems are presented in a case study to demonstrate how they are working practically. This practical discussion leads to a brief investigation of the fluidity within and between these systems.

Broadly speaking, the scientific environmental knowledge system, more prevalent in the urbanized economic North, designates a significant amount of overland flow as waste, to be rushed out of the cities through concrete gutters and channels. In scientific and cultural practices this water changes from overland flow to stormwater once it enters the stormwater infrastructure. Conversely, local environmental knowledge systems, more obvious in environmental practices in those regions not dominated by the economic practices of the industrial North, tend to value all portions of overland flow more positively. This research suggests such knowledge systems are highly unlikely to create a wastewater category similar to that of the scientific environmental knowledge system's stormwater.

While the author readily acknowledges there are more environmental knowledge systems than the two explored here, they remain beyond the scope of this work. Further, the use of the term *scientific* in the context of the scientific approach reflects the post-Enlightenment concept of modernity (Wertheim, 1997, p. 12), although the author is aware of its relationship to many knowledge systems that came before, such as Islamic or Indic knowledge. The decision to use local approaches generally, and Thailand's local wisdom specifically, to contrast with scientific approach's stormwater is because they, superficially at least, appear significantly different to the scientific approach. Further, local approaches have particular relevance to Australian natural resource managers, given the history of indigenous occupation and the many Australians working in Southeast Asia natural resource management sectors.

I am that there are significant changes to the way stormwater is being understood and valued within the scientific approach. Some of these changes are discussed in later chapters. However this research does not seek to investigate changes in stormwater management, rather it investigates how the notion of stormwater became established in the first place, by asking if there is something specific about the scientific approach that would encourage such a construct. The public profile of stormwater reuse increased after the thesis research began. The increased, widespread interest in stormwater reuse/revaluation makes the task of understanding its epistemological origin increasingly important. It would be unwise to debate new understandings and uses of stormwater without critically exploring the origins of the conventional understandings and uses.

The switching between the use of overland flow and stormwater is a conscious choice, reflecting the different values behind overland flow understandings in each knowledge system. The use of overland flow in this document generally refers to local approach or local wisdom understandings, or to express a neutral concept in the scientific approach. In the context of local approaches, overland flow is usually regarded positively. Stormwater, intimately linked with the scientific approach, holds many negative connotations, from dangerous to waste water, in spite of being one portion of overland flow.

In reality, the perceptions and management of overland flow by both knowledge systems is not the stark dichotomy outlined above. Although the early chapters present the knowledge systems separately, later chapters indicate how they sit in different places on a continuum of environmental knowledge systems. There are geographical and conceptual overlaps between these two systems influencing and counter-influencing each other. The geographical overlaps come as both environmental knowledge systems operate, to varying degrees, in both so-called developed and developing societies. Comparing and contrasting of knowledge systems here is not to exacerbate their polarization but to highlight the key drivers behind the stormwater construct by showing the crucial role of their presence or absence.

As it is the conceptual differences, more so than the many similarities, of the knowledge systems that largely explain the absence or presence of a stormwater construct, these are the focus of this research. Focusing on difference allows the opportunity to critically investigate each system's practice to see in what ways the theoretical base remains relevant to contemporary understandings and needs. Even though the research does not deal directly with the merits, or otherwise, of formally merging the two knowledge systems, it demonstrates there are enough similarities for them to be mutually and comprehensively interrogative.

The research goes further than to challenge the stormwater construct through an exploration of the two selected environmental knowledge systems. Also investigated are the challenges to each knowledge system's overland flow/stormwater understandings and practices, and their responses to these challenges. This discussion indicates now is an opportune time, particularly in the scientific environmental knowledge system's evolution, to consider alternative ways of knowing and valuing overland flow. Further it reflects a pragmatic understanding of the relationship between these two knowledge systems.

Methodology

Borrowing widely from academic traditions such as natural resource management, cultural and economic geography and the social sciences, and using literature in English and Thai, the research uses a number of methodological approaches to investigate the stormwater construct. Reviews of the relevant literature are provided in each chapter.

An important concept informing this research is that perceptions of nature are driven by culturally constructed environmental knowledge systems (Braun & Castree, 1995; Peet & Watts, 1996). Bruun & Kalland are quite assertive in this claim when saying, "perceptions of the physical environment are perhaps one aspect of culture where the shared cognition of culture groups manifests itself most forcefully" (1992, p. 3). Berkes agrees that this shared cognition is reflected in environmental knowledge systems and further believes that it can be seen as part of a general process of making the seemingly disordered, ordered (1999, p. 9). Similarly, Singh argues the way nature is perceived reflects the "relationship between human societies and the natural resources in their environment" (2006, p. 358). The structure of these relationships depends on, among other factors, climate, geography, time, local history and culture, the economic system and gender relations (Jackson, 2006, p. 28). As Pederson notes, it is this complexity of factors that makes it is difficult "to find a culturally neutral concept of nature" (1992, p. 149). While many water uses have had their socio-cultural basis explored, stormwater remains a glaring omission.

Accepting Roth's proposition, based on Berkes (1999), that both knowledge systems are "knowledge-practice-belief complexes produced through practice and embedded in culture" (Roth, 2004, p. 3), makes a comparison of these systems possible. As well as highlighting differences in overland flow understandings, another advantage of a comparative study is the is a possibility that alternative, potentially useful, insights into understanding and valuing this water will be encountered (James, 2006, p. 89). This comparative approach is supported by the application of Graham-Gibson's (2003, 2005) community economies to articulate the significance of the economic aspects of both knowledge systems. The different understandings of water environments, as described by D'Souza (2006), are also applied to both knowledge systems. This research argues that acknowledging the influence of economic approaches and water flow understandings are the essential difference in overland flow constructs.

A stand alone case study provides a practical comparison of both systems' influence on the understandings and management of overland flow. The stormwater construct of the scientific approach is explored through the ACT experience and Thailand's local wisdom represents local approaches to overland flow constructs. These examples, although not meant to be definitive of all experiences and possibilities of either environmental knowledge system, remain instructive as to how the process features and values of each system influence overland flow understandings. Interviews conducted during field work in March/April

2007, although limited in value due a change in research focus inspired by the field work, are used to inform the Thai/local wisdom aspects of the case study.

Structure

This examination of the stormwater construct is done in two parts. The first requires an excavation of the stormwater construct from within the originating environmental knowledge system. The second compares and contrasts the finding of the first part with another environmental knowledge tradition – local environmental knowledge systems, represented by Thai local wisdom.

Chapter One investigates the scientific environmental knowledge system influence on overland flow understandings through an examination of the knowledge system's underlying features and values. Chapter Two, building on the information in the previous chapter, shows stormwater to an unsustainable construct, reflective of an environmental knowledge system reliant on the commodification of natural resources and a willingness to control water environments.

Chapter Three examines the features and values of local environmental systems and their influence on overland flow constructs. While a number of process features and underlying values are explored, it is the community economies framework of communities based in the local approach and their willingness to work with uncontrolled water environments that are identified as significant characteristics precluding a stormwater construct. That is, this chapter indicates the possibility of more sustainable ways to value overland flow than as the scientific approach waste product, stormwater.

Chapter Four uses Thailand's local wisdom as a practical example of local knowledge systems' approaches to overland flow, in support of the Chapter Three's theoretical discussion, to further explore the uniqueness of the stormwater. The particular aspects of local wisdom inhibiting stormwater constructs are highlighted, further supporting the idea of the stormwater construct as unsustainable. Public irrigation systems (PIS) are provided as a specific example of systemic local approaches to overland flow. These community managed water supply systems were designed to meet a multitude of water needs, particularly irrigation and production, of small and medium sized villages in Northern Thailand (Urivan, 1995, p. 12).

Written as a stand alone feature, the case study references the preceding general discussions to the specific experiences of the ACT, Australia and Chonburi, Thailand to clearly demonstrate how the values of knowledge systems influence the understandings and management of overland flow. To give the case study focus, wetlands are used as a specific point of comparison. Wetlands' reliance on overland flow for their existence and their complex and varied place in both environmental knowledge systems management practices are key reasons for this choice. The case study suggests the application of the scientific approach in Chonburi, Thailand was done using an inadequate knowledge base on the part of both the introducers and users. Those introducing the scientific approach had an inadequate knowledge of the efficacy and range of existing overland flow management practices and the recipients an inadequate understanding of the underlying values of this new approach to natural resources and their management. The meso scale picture provided by the case study allows the current challenges to both knowledge systems to be more easily seen than is possible in the macro scale discussion provided in the preceding chapters. These challenges clearly demonstrate the conceptual and physical overlaps between both environmental knowledge systems.

Chapter Five picks up on the case study's finding of both systems being challenged, exploring both the nature of these challenges and the responses to them. This chapter remains grounded in the meso and micro scales of the knowledge systems and natural resource management practices and thus is well placed to consider the differences and similarities between each system's overland flow understandings. At these scales the geographical and conceptual overlaps between the two knowledge systems come into sharp relief. The conclusion outlines the major findings of the research, with some practice and policy implications being briefly considered.

Ultimately, this exposure of those values of the scientific approach driving the unviable problematizing of overland flow as stormwater, a neglected aspect in socio-cultural studies of water use, supports attempts to find alternative ways to value all aspects of overland flow.

Ch 1 Overland flow: the scientific approach

> "Thus a 'scientific' interpretation of the world, as you understand it, might still be one of the *stupidest* of all possible interpretations of the world, i.e. one of those most lacking in significance." Nietzsche, 2001, p. 230

This chapter explores the scientific knowledge system (SEK or the scientific approach), in an effort to understand the influence of its features and values on overland flow understandings and management. The characteristics identified are critically applied to stormwater in an initial articulation of how this portion of overland flow is transformed into a waste product. A more complete articulation of the basis of the stormwater construct is presented in the next chapter. It is important to clarify that although the term *scientific* is used in the title of this knowledge system, this does not mean that it has a monopoly on systemic understandings and articulations of the interactions between organisms, including humans, and their environment. It is not meant to suggest that other environmental knowledge systems are unscientific, for it is recognized by many that they are (Unknown, 2005, p. 147). Further, the use of the term stormwater refers specifically to the scientific approach to overland flow understandings and management practices.

Overland flow is described by the scientific approach as "the downslope movement of runoff, other than in defined channels, that occurs as a result of intense rainfall" (Smith, D. 1998, p. 353). Stormwater is defined as the "runoff from roads, roof and other impermeable urban surfaces" (Smith, D. 1998, p. 118) collected in lined or piped drainage systems and deposited in a receiving body of water (Walsh, Leonard, Ladson & Fletcher, 2004, p. 6). These scientific approach definitions clearly show stormwater to be a subset of overland flow. The part of the stormwater definition that refers to impermeable surfaces is somewhat disingenuous, as water that flows across permeable surfaces, such as lawns and forested hillsides can also contribute to stormwater flows. The significant part of that definition, for this research, is the reference to the channelled nature of the drainage system.

Process Features

In spite of the significance of the embedded values, it is generally the process features that are the public face of the scientific approach. The perceived impartiality, objectivity and lack of bias of these processes, as argued by proponents of the scientific approach, are generally considered a consequence of the emphasis on data collection, classification, accuracy and an empirical approach (Fox, Garbuny & Hooke, 1963; McCellan & Dorn, 1999). That is, how overland flow is managed as stormwater is more widely promoted than why it is managed as stormwater.

The scientific approach relies heavily on its empirical tradition (Fox et al, 1963; Foale, 2006). Data collection, along with many other aspects of the scientific approach, including the interpretation and analysis of data sets, has primarily become the realm of formally certified experts. This situation has led to the removal of everyday people from meaningful roles in managing the resources they rely on, encouraging them to be alienated from the resources source and value. (Knudston & Suzuki, 1992; Roth, 2004; Allon & Sofoulis, 2006). For example, the water quality data collected by WaterWatch groups across Australia was not used by any agency or authority until very recently, due to concerns held by experts within the scientific community about its accuracy, in spite of the on-going training provided to participants. In my experience as a local WaterWatch coordinator, the futility of collecting water quality data, particularly during rain events as participants were requested to do, made it difficult to keep volunteers actively involved.

The basis of the empirical tradition comes from "the mathematization... and conceptual unification of the classical and Baconian sciences" (McClellan & Dorn, 1999, p. 299). The use of mathematics in natural philosophy to articulate views of nature began with the Pythagoreans, who "elevated mathematics to the level of the abstract and the theoretical" (McClellan & Dorn, 1999, p. 62). The resultant contemporary focus on mathematically accurate data has positive implications for matters of replication and authentication, but does not always mean appropriate analysis of the data has occurred. The preferred mode of transmission for the collection and accumulation of data and information is the written word (Johnson, 1992). This written tradition, while reinforcing the knowledge system's desire for replication and accuracy, has increasingly placed an emphasis on the use of English (Jianchau & Salas, 2003, p. 135) and some consequences of this emphasis are raised in Chapter Five.

The scientific approach demands for mathematical accuracy see a preference for large data sets over an extended period (Knudston & Suzuki, 1992; Johnson, 1992). In spite of the scientific approach's preference for long-term data sets, Australian natural resource management data sets are relatively short. For example, Australian rainfall data sets collected within the scientific approach go no further back than 1858 (Bureau of Meteorology, 2007), much less in most instances. River flow data is more limited, yet both form the basis of scientific modelling and state policies. The scientific approach's desire for large data sets is limited by the opportunities to generate sizeable data sets and undertake field work (Foale, 2006, p. 130), as well as the broad geographical areas over which research can be undertaken (Johnson, 1992). With many data sets falling short of the ideal, there is a tendency to produce synchronic data sets (Johnson, 1992). That is, there is a reliance on short time series generated over large areas, raising questions about the nature of the accuracy of both the data sets and the models to which they are applied.

One implication of temporally short rainfall data sets is that there is insufficient information to assess data patterns meaningfully, yet they are used to develop water management policies. For example, the approximately 150 years of Sydney rainfall data now strongly suggests that there are roughly 20 year cycles of wet and dry periods (Bureau of

Meteorology, 2007). Yet water management policies were entrenched in a wetter part of the record, using a data set biased toward higher rainfall than it is currently. The gap between the long term rainfall reality and current stormwater practices has become increasingly clear as valuable overland flow is channelled past bare earth yards and locals hoarding recycled reticulated supply, to be discharged at the end of the catchment.

The larger scales of research and analysis of the scientific approach mentioned previously have the advantage of providing a picture of what is happening over large areas and allows for regional comparisons to be relatively meaningful (Fox et al, 1963; McClellan & Dorn, 1999). However working on a regional, or global, scale is not only expensive but allows minutiae to be missed. Differences in ecology and topology, for example, can be underrated or overlooked. A significant result is that all environmental regions are treated similarly and management responses become uniform, regardless of the context or location (Braun & Castree, 1998, p. 34; Lawrence & Breen, 1998, p. 1), as they are responding to the priorities of the scientific approach, not those of the local environment. Stormwater management approaches provide an excellent example of the disadvantages of a uniform approach to natural resource management and this aspect is discussed in Chapter Five.

Employing a transcontextual, global approach is another important feature of the scientific approach and is linked to the process feature of working over large areas. This feature allows knowledge to be applied outside the context in which it was generated (Johnson, 1992), leading to "knowledge not directly based on experience but is deduced" (Pedersen, 1992, p. 153). That is, a theoretical approach to knowledge generation and application is encouraged in the scientific approach. This is linked to an important theoretical scientific approach concept, that of utility. This theory's underlying premise, that "science and scientific endeavours can promote human welfare and should therefore be encouraged" (McClellan & Dorn, 1999, p. 245), works with the transcontextual nature of the scientific approach to encourage its extension into other environments and cultures.

The scientific approach relies heavily on classification (Fox et al, 1963, p. 315; McClellan & Dorn, 1999, p. 296). Water alone is classified in many ways. It can be classified by the descriptive categories of fresh, salty or brackish, or according to location such as groundwater or river water. It can also be classified according to purpose, such as irrigation water, reticulated supply or waste water, such as stormwater and sewerage. There are also many ways to classify the properties of water, be they physical (such as pH or salinity) or pollutant load properties (including heavy metals and chemical elements). Some of these classifications overlap, for example potable supply is fresh water with specific physical and pollutant load properties. Other categories are mutually exclusive, such as salt water sources and reticulated supply. This diversity in classification reflects the difficulties encountered in attempts at systematic descriptions of the water experience due to the variations in the importance of hydrological processes found at different scales as

> "there is no fundamental theorem or universal law from which all hydrological behaviour can be deduced. As an observational earth science, the methods used in hydrology rest on the methods and assumptions of its composite scientific and engineering disciplines" (White, 2004, p. 19).

Attempts at systematic accounts of natural processes are regarded as a key activity of the scientific approach (Fox et al, 1963, p. 343). These accounts are empirically based and rely on the collection of mathematically accurate written data sets neatly classified and elucidated in terms of theories and laws. It is these grand accounts of the world and the processes supporting them that are used in the public presentation of the scientific approach as a rational, objective and impartial knowledge system. Yet less readily acknowledged by the proponents and beneficiaries of the scientific approach are those values embedded in the scientific approach informing the data generation, analysis processes and theory development.

Values

Underpinning the scientific approach process features and driving the understanding and management of nature, including overland flow, are a number of values. At this level it is the priorities and ethics forming the basis of the knowledge system that are under question. Focusing on the underlying values of the scientific approach draws attention to the influence they have on the way overland flow is understood. How these values combine to build the stormwater construct is discussed in more detail in the next chapter.

The complex place of technology within the scientific approach is reflected by it being an important process feature, but also an important embedded value. That is, not only is technology important to the processes of the scientific approach, it also represents a philosophical commitment to the capacity of technology to solve an expanding range of problems, while making life more comfortable and prosperous for more people (Ullrich, 1992, p. 275). Technology has developed inexorably with European science. Smith, N. is forceful in his assessment of this relationship when stating "technological intent is...written into the scientific attitude" (1998, p. 276). Science and technology are now so intimately associated that much contemporary scientific research could not be done with out it. For example, the first opportunity to observe hydrological properties across broad scales came with the remote sensing capabilities of Geographical Information Systems (White, 2004, p. 13).

At the smaller scales of urban stormwater systems, technology applied in the familiar channel and gutter concrete infrastructure is less complex than that applied to other uses of overland flow. Streams are straightened and concreted with guttered urban streets plumbed into them via gravity fed concrete pipes. The collected water is then discharged, without use, into a receiving water body, generally a river or large lake and in most cases with only limited pollution management such as gross litter traps and screens. The consistent application of this simple technological infrastructure over time, in the face of massive technological change, is indicative of the lack of economic and social value applied to this portion of overland flow that becomes stormwater. Interestingly, as stormwater is being transformed from a waste product to a resource, the complexity of technology applied to its capture, storage and treatment is increasing. This relatively new phenomenon is considered further in Chapter Five.

The use of increasingly complex technology has led to a reliance on technical experts. As either the designers or managers of the technology these experts, and their machines, increasingly act as environmental gatekeepers (Ullrich, 1992, p. 285), given their greater influence in setting water management policy and directly managing water sources. In terms of stormwater, these roles have largely been left to engineers. However, given the study of engineering can "quenches [sic] the intellectual curiosity in hydrology" (White, 2004, p. 25), unconventional or creative approaches to overland flow management can be discouraged. Further, technology's complexity and gate keeping tendencies has contributed to the feeling of being disconnected from nature common to residents of industrialized urban locations. That individuals' in industrialized communities can become disconnected from their water sources, losing sight of their value through the application of complex water management technology, an increased reliance on out-of-catchment experts and the loss of meaningful roles in water management, is convincingly shown by Strang's (2004) study of historical water management changes the Stour Valley in the United Kingdom.

The scientific approach, as part of contemporary science, fiercely defends it secular, rational framework. Yet this denies the vital support provided by the Christian church to early western European science. It was only as its fields of enquiry began to butt against Christian cosmology that the scientific approach began to find an independent voice (Wertheim, 1997, p. 152). Wertheim argues the erosion of the religious foundation to modern scientific enquiry came with the use of increasingly "sophisticated analytical techniques and observational tools" (1997, p. 130). The greater the erosion of the religious base, the less space that has officially been provided for spiritual explanations of how the world works (Alvares, 1992; Johnson, 1992), to the point where there is now extremely limited tolerance for anything other than strictly secular understandings. Thus, the contemporary scientific approach can be seen as being founded on the rejection of the spiritual or supernatural (Byrne, 2007, p. 2).

This rejection has contributed to the loss of the sense of water's sacredness within the scientific approach. That is, there is a loss of those "values which enable us to save and share water" and an acknowledgement that "water has vital social, cultural and ecological roles to play that cannot be protected purely by market forces" (Foskey, 2006, p. 75). Removing these sacred elements erodes the sense of interrelationship between humans and the environment, and the knowledge system is one step closer to presenting environmental features as more readily open to human control.

In spite of the scientific approach's overt rejection of any religious aspect, Wertheim convincingly argues the work of the sciences, especially physics and mathematics, retain elements of Christian cosmology in both explanations and motivations (1997). For example, she notes Stephen Hawking has equated the "theory of everything" with "the mind of God" (Wertheim, 1997, p. 13). Further, that some physicists refer to the Higgs bosun particle as "the god particle" reflects the biblical role of god the creator (Wertheim, 1997, p. 12). These lingering, unspoken elements influence notions of gender and the right to control the environment. One legacy of the religiosity attached to modern science is the exclusion of women, and their knowledge, skills and perspectives regarding water management and uses (Wertheim, 1997, p. 11; Strang, 2004, p. 24). The gender inequities found in the scientific approach are compounded as women are "at the intersection of economic, social and political disadvantage" (Foskey, 2006, p. 76) and remain more likely to be collecting and distributing water at the micro level, as men continue to dominate the macro decisions about water collection, management and allocation.

The lingering Christian cosmology also helps account for a sense of the right to control the environment solely for human benefit pervading the scientific approach. For example, Strang (2004) has effectively articulated how notions of Christian cleanliness influenced water management and use, from sourcing and treatment to the increasingly volume used. Following the move away from the Church this sense of environmental entitlement was rephrased by philosophers, but retained nonetheless (McClellan & Dorn, 1999, p. 246).

The relationships between the features and values of the scientific approach articulated in this chapter present a rigid structured system, reliant on controlling the environment – physically, intellectually and economically. Driven by principles of universality and utility, an inflexible, one size fits all approach is created where information useful to the scientific approach is excluded as it does not strictly fit either process or value criteria of the knowledge system. This confidence on the part of the scientific approach is unsurprising, given the closeness of locations, motives and cultures involved in its development. Yet its inflexibility is a bit disquieting. For example, individual science disciplines are separated more as "a convention dictated by convenience" (Fox et al, 1963, p. 4), rather than reflecting any substantial difference in disciplines. This inflexibility is reflected in White's point about stormwater being primarily in the engineering domain, while overland flow is located in geographical fields of study (2004, p. 4). Yet they are the same thing, from different perspectives.

These values as articulated already give some sense of why the stormwater construct could seem logical within the scientific approach. Given technological mastery; that nature is here for human exploitation; that people's connections to non-human worlds are severed; and the range of potential applications for overland flow, it is unsurprising that aspects of overland flow would be categorized. Further, moving environmental features, such as water bodies and channels, for human convenience to support those categories is almost to be expected.

Yet there remain two key values of the scientific approach that ensure the construction of a stormwater category. The first is a strong preference for controlled, preferably channelled, water environments stemming from the sense of the right to control natural processes found within the scientific approach. The second value is the reliance on the commodification of environmental processes and features, including overland flow, to price their values. That the scientific approach is unable to work with water's physical and cultural diversity (Gibbs, 2006, p. 73) is shown by its constant desire to control its flows and value it primarily in economic terms. The next chapter demonstrates how the stormwater construct is a consequence of these desires.

Ch 2 Stormwater: overland flow as a waste product

> "Thus, nature is continuously appropriated - and remade - as part of the "species existence" of humans. But this tells us little about how "needs" become defined, or for that matter, what objects are taken up to meet "needs", or even how this is organized socially." Braun & Castree, 1998, p. 16

Nineteenth century urban health concerns about the dangers of still water led to the idea that water must be constantly moving through cities. Swnygedouw, (2004, p. 32) has shown that from these concerns, stormwater became just one part of a larger water circulation system, including sewerage and reticulated supply, designed to promote civic flow. Other conventional explanations for stormwater usually revolve around flood prevention and the protection of private property (Walsh, Leonard, Ladson & Fletcher, 2004, p. 6).

This chapter, starting from the point that stormwater is a construct, shows the pre-eminent values of the scientific approach to perceived problematic overland flow to be to control and commodify water environments. There is distinctly limited recent research into why, or if, this construct and the associated discourse and infrastructure, was an appropriate response to these concerns, or if these remain legitimate concerns, in the face of negative stormwater consequences, such as increased flow rates, decreased water quality or the loss of possible alternative economic uses for example. Even a brief examination of the scientific discourses around stormwater shows it to be a failing construct. For example, the futility of water rushing by, to be dumped, is obvious in times of extended low annual rainfall. Once a certain construct is reasonably entrenched in popular psyche, a range of measures tend to be built on the hypothesis to find 'better use' of the stormwater. Indeed, there have been some attempts to bring intangibles such as community values within the ambit of scientific discussions. The CSIRO, for example, has researched community values regarding drinking recycled stormwater (Po et al, 2005), but it did not investigate why it is seen as wastewater. Others have considered the social implications of non-conventional stormwater management practices (Mitchell, Mein, & McMahon, 1999; Lloyd, Wong & Chesterfield, 2002), but no questioning of the construct itself. It appears to be widely accepted that references to flood mitigation or property protection or public health considerations (Lloyd et al, 2004; p. 2) are adequate justification for the stormwater construct.

In spite of the claims that stormwater systems would reduce flooding threats, it is now widely accepted that stormwater management practices and infrastructure change the local hydrology in a number of ways, including an increase in flash flooding, more and faster overland flow and changes in water quality (Chiew, Mudgway, Duncan & McMahon, 1997, p. 1-2; Lawrence & Breen, 1998, p.3; Walsh et al, 2004, p. 9). Even dams, which store that portion of overland flow designated as useful, that is irrigation or reticulated supply, do not always fulfil their secondary service of flood protection as they sometimes "aggravate damages when floods do occur" according to World Commission of Dams report (in IBON Foundation 2005, p. 59). Thus, when considering concerns about increased peak flow and discharge rates and water quality considerations, combined with greater perceived water scarcity, the discourse of the stormwater construct seems incongruous with the reality of stormwater outcomes.

Due to the overt focus on flood mitigation and property protection, and more recently, pollution control, stormwater research has traditionally focused on engineering perspectives of its management (Chiew et al, 1997, p. 1; Lawrence & Breen, 1998, p. 1; White, 2004). Increasingly, attention is being paid to alternative ways to manage, use and value stormwater, such as recycling and water sensitive urban design (WSUD). This attention shows "...stormwater... are [sic] being re-evaluated as resources [sic] to be utilized, rather than seen as waste products [sic] for disposal" (Mitchell et al, 1999, p. 4). Chapter Five discusses these changing approaches to stormwater further.

This is timely attention, given that annually both Melbourne and Sydney expel marginally less stormwater than the volume of reticulated water supplied (Mitchell et al, 1999, p. 3). The values behind these alternative approaches vary widely, with many incorporating a less engineering or technical focus than previously. Yet are all are occurring without a clear understanding of how some portions of overland flow became a waste product in the first place. Rather than accepting the standard explanations for stormwater of public health and safety at face value, this chapter critically examines the stormwater construct, as Byrne (2007, p. 2) observes, "we need to be willing to excavate our own practice in order to know how it is constituted". This excavation uses similar concepts to critique stormwater as those used to research the socio-cultural aspects of other (particularly urban) water uses (Swyngedouw, 2004, p. 33). In spite of the powerful insights from this research and the range of water uses investigated, none address stormwater directly or specifically.

Chapter One identified important process features and values of the scientific approach. Briefly, important features include an empirical, classification approach with the resultant theories applied in a transcontextual manner. These features are supported by values of secular rationality, a reliance on technology and the right to control nature and its processes. The stormwater construct is encouraged by the interrelationships between these underlying process features and values. For example, a reliance on technology is important to the construct, as it is only as overland flow enters the technical train does it become known as stormwater. Further the technological capacity allows multiple systems, such as a stormwater, sewerage and the reticulated supply system, to both operate individually and collectively in a complex water management process.

In spite of the in-built tendency to the stormwater construct, there are two additional, key, values of the scientific approach, briefly identified at the end of the previous chapter, vital to the construct. These values are i) a preference for controlled, preferably channelled, water environments and ii) a reliance on commodification as the primary attributor of the value of a natural element such as water. This chapter discusses the role of these key values in cementing the stormwater construct.

Controlled water environments

The previously identified sense of the right to control the environment found in the scientific approach provides a strong basis for its preference for controlled, preferably channelled, water environments. Indeed, being channelled is explicit in the stormwater definition provided in Chapter One. Generally the natural resource management practices of the scientific approach ascribe natural processes and elements a passive role in their behaviour and continued existence, as the approach is underpinned by a "naturalized concept of nature" (Palmer, 2006, p. 36). Although this concept of nature does, as Palmer demonstrates, exclude indigenous environmental management practices from scientific environmental management practices (2006, p. 36), it also encourages nature more broadly to be portrayed as waiting to be defined, and acted upon, by people. A naturalized concept of nature, with the help of technology, allows the alternation of landscapes and natural processes. This naturalized concept can be seen in many water environments. For example, cloud seeding is a technological intervention into the hydrological cycle, used in both Australia and Thailand, to induce rain. That is, the hydrological cycle is deemed to require assistance to provide the volume of overland flow required by human societies. In terms of contributing to the stormwater construct, this concept is reflected in the straightening and concreting of natural channels and the draining wetlands.

Human culture, religion in particular, shapes the naturalized concept of nature. Indeed, "naturalized" nature is a secular articulation of an earlier, historically important, Christian belief of the right to control nature. For example, Strang sees many secular uses of water as steeped in Christian beliefs, such as cleanliness and morality (2004, p. 32). This combination led to the establishment of widespread water management and distribution practices, and new water consumption patterns by the early 19th century (Strang, 2004, p. 32), which, in trun, led the establishment of increasingly sophisticated controlled water environments. This assumed right to such practices and patterns were retained by the scientific approach, and rephrased (and magnified), to justify the control of nature condoned by the scientific approach.

The desire to control water environments is intertwined with other aspects of the scientific approach. Increasingly sophisticated and reliable technology, for example, generates an increased confidence in the right to control nature. Further, a reductionist approach causes the different parts of nature to be separately identified, and broken, isolated into their smallest component. At this level it appears to become easier to control nature. It also encourages the application of scientific environmental knowledge in a wider range of situations that it was developed.

D'Souza explains the quest to control water environments through a lens of Marxist philosophy; for him, water or river control efforts were heightened during the colonial periods as land became a capitalist commodity (2006, p. 16). His study of dam construction on the Mahanadi River in eastern India showed how the colonial authorities use of different measures to value the worth of waters ultimately led to large scale social, physical and hydrological changes in the delta. In a similar manner it could be argued the overland flow controlled through stormwater infrastructure, as well as stormwater constructs, allows the simultaneous physical and conceptual division of overland flow.

Commodified water environments

The commodification ethic embedded in the scientific approach has led to nature becoming understood as "natural resources" (Katz, 1998, p. 46). That is, commodification allows the environment to be seen as a source of free materials, waiting to be transformed into a product (Katz, ibid). The early coupling of capitalist economics with the development of the scientific approach is shown by Newton completing a presentation on his groundbreaking and complex hydrodynamics principles in terms of it being good for ship building (McClellan & Dorn, 1999, p. 246). This demonstrates the need for the commercial application of any so-called pure science finding to be made clear to the merchant/capital classes, to ensure their on-going support of scientific endeavours. This reliance on commodification to value natural processes and features is the second key value of the scientific approach driving the stormwater construct.

The commodification process allows overland flow management to become one aspect of a capitalist accumulation strategy (Katz, 1998, p. 46), rather than a strategy to support a community's practical and social water needs. For example, as reticulated supply was increasingly seen as a necessary part of industrialization, its pre-eminence was ensured by prohibitions on both household storage for those on reticulated supply systems and on harvesting directly from natural waterways. A lack of prohibitions on stored rainwater at a household level limits the effectiveness of the commodified reticulated supply by inhibiting the accumulation of capital through reduced demand. Yet reticulated supply is essentially nothing more than overland flow stored in large dams before undergoing a complex treatment train and piped to supply highly localised points such as household taps and toilets. Reticulated water is a positively regarded overland flow category.

The commodification imperative of the scientific approach forces the division of overland flow into differently valued categories. The success of overland flow categories based on commodification imperatives (irrigation, industry and reticulation, for example) required juxtaposing overland flow categories with no direct economic value to be constructed. That is, some portions of overland flow were required to be designated as wastewater, such as stormwater, and transformed into economic externalities. In contrast to the positively valued commodified water, the waste water categories are largely negatively perceived, in spite of the valuable cleaning and pollutant transport services this portion of overland flow can provide. Consequently not only is there a material transformation, such as the water being diverted in stormwater infrastructure and the resultant deterioration in quality, but values are also exchanged (Braun & Castree, 1998, p. 43).

As with controlling water environments, their commodification is also a result of interrelationships between the features and values of the scientific approach epistemology. For example, commodification of overland flow is made easier by technology, due to the ability to mass produce and take advantage of scales of economy. It is logistically easier for water providers to connect all households to reticulated supply than to provide and maintain individual water tanks or a series of small scale water treatment plants or wetlands in each catchment within its administrative boundaries. The commodification of overland flow has also contributed to the reduced sense of a sacred and direct connection to raw water noted in Chapter One. As what Swyngedouw describes as the "non-economic uses and functions of water" (2004, p. 41) become increasingly constrained by the economic uses and values, the role of the sacred diminishes and commodification assumes greater importance and objective relationships are placed above social relationships (Ullrich, 1992, p. 285). Under such circumstances Strang has shown, in Dorset's Stour Valley (United Kingdom), that the place of female water deities has been quashed and women's roles in water management and distribution have been radically altered (2004, p. 24-25).

Transforming water environments

The stormwater construct satisfies the interrelated commodification values and desire to control water environments of the scientific approach. Most overland flow is controlled, with some designated to satisfy human demands such as household, irrigation or industry purposes. This portion of water is transformed into a capitalist commodity from which profit is sought. Another portion is transformed, economically and socially, into the externality stormwater. Thus stormwater exists to allow the capitalist exploitation of other portions of overland flow, such as reticulated supply. By combining this intellectual understanding with technological interventions, a wastewater friendly landscape of concrete drains and channels was created.

Given Swyngedouw's argument that knowledge systems and socio-cultural norms are a reflection of a specific historical point (2004, p. 19), it follows that these norms must change as situations change. For this reason the traditional divisions of overland flow can not remain static. Indicators of water scarcity and the capitalist imperative of continuous growth have combined to see the intellectual and physical mining of the stormwater construct, to source both water and profits. As demands for water grow, stormwater is becoming a hypercommodified product as the extensive boundaries of global water sources are met and what was once an economic externality is transformed into a resource, valuable in its own right. Chapter Five explores current challenges to the stormwater construct and outlines some responses, including hypercommodification, to these challenges.

Clearly the stormwater construct is a product of the interrelationships between the features and values of the scientific approach, particularly the preference for controlled and commodified water environments. This construct has led to a problematic discourse of waste, danger and control. This discourse is becomingly increasingly dominant globally, supported by an unwillingness to questioning its on-going validity and in spite of the increased demands for water supply. The articulation of the stormwater construct as presented here is useful not only as it is one of the few stormwater specific socio-cultural excavations. It is also timely, given the recent growing interest in turning stormwater from waste to a resource. By providing a more realistic portrayal of stormwater's basis, the capacity to transform it from a waste to a resource is provided a better footing than that afforded by property or public health protection claims. Revealing the unsustainable nature of the stormwater construct means alternative, preferably more positive, understandings of overland flow are needed.

To highlight the significance of the preference for controlled water environments and commodification in forging the stormwater construct, the following two chapters discuss what process features and values of local environmental knowledge systems preclude the likelihood of a stormwater construct. Although later chapters contrast these two knowledge systems and it is possible that local approaches may provide alternative overland flow understandings, the answer is not as simple as transferring values from one knowledge system to another. Rather, what is shown is the range of knowledge system values and their overriding influence on natural resource constructs. By demonstrating the influce of knowledge systems, a reasonable place to continue excavating knowledge system natural resource constructs is provided.

Why Local

Local environmental knowledge systems, as variously named, have enabled communities to distribute and manage natural resources on a long term basis for their on-going existence (Berkes, 1999, p. 8). Although not always successful (Berkes, 1999, p. 59), there are many examples of successful local management practices. It is this positive management capacity that has attracted the attention of researchers and practitioners of natural resource management from the scientific approach. This has led to some within the scientific approach to consider combining elements of both knowledge systems, in an effort to produce more sustainable natural resource management outcomes (Berkes, Colding & Folke, 2000, p. 1251 Moller, Berkes, Lyver & Kisialioglu, 2004; Foale, 2006, p. 135). The perceived usefulness of local knowledge systems comes from both the similarities with the scientific approach (Roth, 2004; Huntington, 2000, p. 1270) and also, significantly, the differences from them (Berkes, 1999, p. 14).

For the purposes of this work, local environmental knowledge systems are viewed as synonymous with *indigenous environmental/ecological knowledge* and *traditional environmental/ecological knowledge* systems (Ford & Martinez, 2000, p. 1249; Goodall, 2007, p. 3). They have also been expressed as *ethnosciences* (Berkes, 1999, p. 38; Rist & Dahdouh-Guebas, 2006). The term *local* was deemed more useful, over the common terms of *traditional* or *indigenous*, for a number of semantic reasons. The use of the term t*raditional* is problematic due to connotations of "simple, savage and static" (Warren quoted in Berkes et al, 2000, p. 1251) and resistant to change (Goodall, 2007). Such connotations are an anathema to the nature of local environmental knowledge systems as many have proven to be resilient and adaptable natural resource management systems (Berkes, 1999, p. 159). *Indigenous*, although perceived by some as "less value laden" (Berkes et al, 2000, p. 1251) holds little meaning to researchers of Thailand as the highly contested, extended and extensive history of many flows of migration by many peoples, in, out and around what is now know as

Ch 3 Overland flow: the local approach

> Martha: "But there is no such thing as magic!"
> The Doctor: "Well, it's just a different sort of science. You lot, you chose mathematics - given the right string of numbers, the right equation and you can split the atom. The Carrionites use words." From Dr Who "*The Shakespeare Code*" Episode 2, Series 3, 2007.

This chapter investigates local environmental systems (LEK or the local approach) to demonstrate an alternative view of overland flow. Understanding how the features and values of local knowledge systems influence the understandings and management of overland flow reinforces that it is a preference for controlled and commodified water environments that allows the stormwater construct to seem appropriate. This investigation focuses on two values in local environmental knowledge systems that significantly contribute to an explanation of why local approaches generally have no place for a wastewater category akin to stormwater. The first feature is the willingness of local approaches to work with uncontrolled (temporally or spatially) water environments. The second is the nature of the economic practices and transactions embedded in local environmental knowledge systems.

Provided here is a necessarily broad understanding of local approaches to overland flow. This is due largely to the frustrating combination of i) an overwhelming diversity of local approaches, where for any example provided a counter-example is likely to exist; and ii) limited direct research on the epistemological characteristics of overland flow in local approaches. Representing a practical, not exclusionary, decision, the majority of examples provided in this chapter are from Asian local approaches. Chapter Four's investigation of a specific local approach – Thailand's local wisdom – adds practical substance to the largely theoretical understanding of overland flow within local approaches.

Thailand (Jumsai, 1997, p. 9) combined with the historically relatively limited direct colonization experiences (Winichakul, 2004, p. 131) means Thai understandings of *indigenous* are so "relational and unstable" (Goodall, 2007, p. 2) that it is of limited application to this research.

The advantage of using *local* is that it allows for a broader understanding of whose environmental knowledge is considered legitimate than is suggested by either *traditional* or *indigenous*. While contributing to the diversity of local approaches, the introduction of other knowledge systems covered by *local* does not detract from the basic similarity in principles and values across the systems. Rather it reminds researchers and policy makers that it is not only indigenous peoples who hold environmental knowledge outside of the scientific approach by encompassing the environmental knowledge of the many groups in a community or region.

Environment was chosen over *ecological* largely due to concerns about that term being a direct product of the scientific approach. It could be conceptually incongruous to use a term from one knowledge system to identify both. Even if a less formal understanding of ecology were used, as suggested by Berkes (1999, p. 6), still missing is the spiritual element so pervasive in the local approach. That is not to say that *environment* immediately conjures up images of spirits or unexplainable forces at work rather that, for me, it use allows for a greater range of the unknown to be encountered and explored than is offered by *ecological*.

At this point it is important to again acknowledge that the use of *scientific* to name one epistemological community does not detract from the science inherent in another. There is widespread agreement that the local approach is a science based and systematic environmental knowledge system (McNeely & Wachtel, 1990; Uraivan, 1995; Huntington, 2000; Moller et al, 2004; Goodall, 2007), whose outcomes can be considered "analogous" to those of the scientific approach (Dwyer quoted in Berkes, 1999, p. 153). It has also been argued that the widespread application of local approaches makes it the "peoples' science" (Richards quotes in Berkes, 1999, p. 34). The usefulness of the term *ethnosciences* to capture local environmental knowledge systems as dynamic forms of science (Rist & Dahdouh-Guebas, 2006) becomes apparent in this context.

Initially investigated by the social sciences (Johnson, 1992; Berkes 1999, p.4; Huntington, 2000), aspects of local environmental knowledge systems are increasingly being used in by the scientific approach in natural resource management (Berkes et al, 2000, p. 1259; Moller et al, 2004; Foale, 2006; Rist & Dahdouh-Guebas, 2006). The initial emphasis on social science research seems to have generated more, apparently, unscientific information, about spiritual and social customs supporting natural resource management principles and practices, than commonly found in physical sciences research. This breadth of information is likely due to the social sciences being more interested in cultural and human-spiritual beliefs than in the physical sciences, where physical and human-physical interactions prevail. The social science approach may also help explain the limited work on local approaches overland flow understandings, as it could be seen as too much part of the physical sciences tradition for social scientists.

In terms of the types of readily available research undertaken by scientific approach practitioners regarding local approaches resource management practices, there is a distinct emphasis on forestry and fishery practices (Mackinson, 2001; Silvano, Udvardy, Ceroni & Farley, 2005; Friend, 2007). This focus reflects the obvious economic activities of the local communities. The scientific approach is also interested in forestry and fishery practices. River fisheries, common in Thailand, are particularly reliant on overland flow for their existence, with any overland flow knowledge embedded in fishery discourses. As a general observation, it appears research into local environmental knowledge driven by the priorities of practitioners of the scientific approach are less readily able to articulate the embedded aspects of these knowledge systems than similar research driven by the priorities of the local approach practitioners. In the first case, when research is driven by the priorities of the scientific approach, it is not unusual for the knowledge contained within the local environmental knowledge system to suffer as a result (Chiengthong, 2003). The nature of these consequences will be further explored, with an emphasis on the overland flow understandings and management of Thailand's wetlands, in the case study and Chapter Five.

Following is an articulation of local approaches in terms of the i) process features: that is, how the knowledge system works at collecting and presenting information; and ii) values: those priorities directing the environmental constructions and the choices about what is legitimate information and why. The last part of this chapter outlines how the process features and values identified combine to make the notion of stormwater untenable in local knowledge systems. Given the diversity of local approaches, this chapter remains largely theoretical. Chapter Four brings a practical aspect to the understanding of local approaches by investigating a specific local ecological knowledge system, Thailand's local wisdom.

Process Features

Local environmental knowledge shares an empirical based with the scientific approach, guided as it is by experience and observation and involving prediction and hypothesis (Johnson, 1992). These observations and experiences come from living in the local environment allowing knowledge and skills to be acquired from practical and experience-based learning. A contextual development and application of knowledge about the elements, plant and animal behaviour, and their interactions can lead to the "existence of effective indigenous strategies for ensuring sustainable use" (Johnson, 1992, p. 3) of the local environment.

The data collected in local knowledge systems, based on observation and experience as with the scientific approach, are generated by the resource users (Johnson, 1992). There are few experts, as understood by the scientific approach, guiding either the collection or interpretation of the data. While many local knowledge systems have "well-respected local experts" (Berkes, 1999, p. 152), including in fields of water management (Urivan, 1995, p. 53; Jianchu & Salas, 2003, p. 139), systems of accreditation are markedly different from those found in the scientific approach in that they tend to be less structured, formalized or contested and holding a such a position usually takes years of practical training and community support (Jianchu & Salas, 2003).

Local approaches primarily generate diachronic data sets (Berkes, 1999, p. 10; Johnson, 2000). That is, the data relate to one, usually small, locality, over a long period of time. Long observation periods found in the data sets of the local approach are often cited as an important feature of these systems (Johnson, 1992; Huntington, 2000; Folke, 2004; Moller et al, 2004). Ironically, practitioners of the scientific approach often lack long-term detailed data sets (Foale, 2006, p. 130), yet there is a wealth of information held in communities strongly connected to local landscapes. There are exceptions, with some examples of data relating to large tracts of land, such as Native American buffalo hunts (Berkes, 1999, p. 100) and some indigenous Australian communities (Knudtson & Suzuki, 1992, p. 129).

A consequence of extended time frames for observations of small areas is the strong likelihood that the knowledge will be quite detailed (Johnson, 1992; Berkes et al, 2000, p. 1257; Huntington, 2000; Moller et al, 2004; Rist & Dahdouh-Guebas, 2006). While operating at such scales can mean problems in terms of the completeness of the knowledge available locally (Foale, 2006, p. 132), there is a strong likelihood that the information gathered will be relevant to the users' direct needs (Knudston & Suzuki, 1992). Further, the local approach's more directed focus on smaller areas can have positive outcomes for natural resource management as everyone is involved in the management of environmental resources (Johnson, 1992). That is, community members are not isolated from the resources they use, as often happens with the scientific approach. Although most have some role in natural resource management, these roles are not equally distributed (Jianchu & Salas, 2003, p. 135)

Notions of accuracy are more practical in local approaches than those found in the scientific approach. This is to say, "it is a difference of degree (quantitative) rather than type (qualitative)" (Giarelli quoted in Berkes, 1999, p. 10), of data collection and use in either knowledge system. This quantitative difference has led to responses ranging from claims that the information garnered from local approaches can not be applied to scientific models through to the situation where scientists have refused to work with alleged non-scientists (Huntington 2000, p. 1273). That some information may not be accurate by the standards of the scientific approach, however, is not an adequate reason to dismiss the usefulness of the knowledge system. At best such a position is short-sighted; at worst it represents intellectual inflexibility and prejudice.

Additionally, some of the perceived inaccuracies encountered are likely to be product of cross-cultural or linguistic misinterpretations. For example, the "inertia" (Huntington 2000, p. 1273) in categorizing now favours the established scientific approach, leading to an apparent need to describe local approaches in terms of the scientific approach. However the concepts of local epistemologies can not be readily categorized according to those of the scientific approach. Attempts to interpret such concepts in terms of scientific discourse, cramming them into familiar, yet ill-fitting categories, are not only futile but defeat the purpose of exploring alternative knowledge systems (Ford & Martinez, 2000, p. 1249) and add to misunderstandings and misconceptions. The absence of an obvious scientific discourse, as understood by the scientific practitioner, in the language of local knowledge systems, or even reluctance on the part of the local knowledge practitioners to share their information, may also stifle research activities (McNeely & Wachtel, 1990, p. 311; Knudtson & Suzuki, 1992; Huntington, 2000, p. 1273). Ultimately, it is the responsibility of the prudent researcher to cast a critical eye over data; sometimes that critical eye needs to be accompanied by an open mind.

The construction of data sets almost inevitably leads to classification. Johnson (1992) points to anthropological studies showing that all societies classify, often with a close correlation between local and scientific approaches. Others note the tendency of these knowledge systems to classify animals, plants and objects (McNeely & Wachtel, 1990; Foale, 2006). Specific examples of local approach classifications are provided in the context of local wisdom in Chapter Four. From collection to classification, the next step is to offer explanations for what has been observed. In spite of sharing the observe-hypothesise-test model with the scientific approach, local environmental knowledge systems are likely to offer a spiritual component to any explanation of the phenomena observed (Knudtson & Suzuki, 1992), unlike the scientific approach. For example, the role of spirits in water management is common to explanations of overland flow (or lack of it) (McNeely & Wachtel, 1990; Johnson, 1992; Choochat, 2000).

The accumulated knowledge of these systems is primarily transmitted in oral and other non-written practices such as dance, song lines and drawing (Goodall, 2007; Johnson, 1992), with layers of information provided. For example, some Indigenous Australian communities drawings of concentric circles can represent a camp site, well, rock hole or breast. Concentric circles linked by squiggly lines represent waterholes connected by running water. This symbol, and many others, whether drawn on bark or in the dirt, can be used to transmit environmental knowledge of the landscape or simply tell the way (Arthur & Morphy, 2005, p. 20). Acknowledging the relative dominance of non-written communication in local approaches in no way excludes written traditions.

The technologies employed by local approaches are usually less complex than those adopted by the scientific approach. Contrast, for example, the use of pre-existing wetland features to store seasonal overland flow with the construction of large dams to store many years of water supply. There is also generally less reliance on technology to achieve the resource distribution and management aims of the local communities, with other options, such as spiritual practices, as readily applied as technical ones to problems solving and productivity matters. Indeed, the Hopi of North America have an origin story that includes an explicit warning against relying on technology (Whiteley & Masayesva, 1998). The simplicity of many forms of technology, including their being constructed of locally sourced and often renewable materials, limits, but does not negate, the human impact on the environment. In the Anangu Pitjantjatjara (AP) Lands, in northwest South Australia, planting around homes is done in dirt mounds that collect and store overland flow (James, 2006, p. 97). By limiting their environmental impacts and using locally sourced materials, these communities are able to maintain their vital connections with the environment (McNeely & Wachtel, 1990). It is the practically based and locally sourced nature of local knowledge's technology that sees it remain a process feature of the knowledge system, in contrast to its dual role as both feature and value of the scientific approach.

Values

The more substantial motives and conceptual underpinnings of values not only contribute to the diversity of local approaches but also sharpen our awareness of the fundamental differences between these two broad knowledge systems in the understandings and management of overland flow. Some of these underlying values are reflected in the process features and these connections are identified as relevant.

Relationships between men and women, and their respective cultural roles, have long influenced the control of, access to, use of and values given to water (Strang, 2005). In local knowledge systems, particularly in Asia, maintaining the balance between the masculine and feminine (as part of the duality represented by the well known yin yan symbol) is fundamentally important and quite obvious in spiritual practices (McNeely & Wachtel 1990). Although there is limited academic and institutional attention given to

> "gender in human interactions in water... Similarly, research has rarely considered the gendered meanings encoded in water, or how these are manifested in material terms" (Strang, 2005, p. 21).

This neglect is despite the greater burden in securing and managing household water supply falling on women being well documented (Foskey, 2006, p. 66). Outside of the shared labour of farming, women are generally responsible for most daily household chores (McNeely & Wachtel, 1990, p. 145), many of which revolve around water in some way. The water beliefs of a community can influence how these activities are undertaken. For example in India's Ladaki region local knowledge, the nature of stream worship is such that no polluting activities can be undertaken in, on or around them (Agarwal & Narain, 1997, p. 33). This means clothes must be washed well away from them, with the women needing to cart river water to the washing location.

Women are frequently the holders of medicinal knowledge (McNeely & Wachtel, 1990), thus indicating an intimate knowledge of local plants and herbs. There are many other examples of environment knowledge being stratified along gender lines, but they are not directly relevant to this work. What is relevant is that the access to, and use of, some environmental knowledge in local approaches can be distributed on a gender basis while other knowledge can be widely distributed throughout the community. It is also important that such allocations of community work be view through more than your personal value system. For example, what may be considered women's domestic handicrafts of preparing weaving materials by an inhabitant of the urbanized North, is considered important "women's warfare" (McNeely & Wachtel, 1990, p. 83) by some communities in Borneo due to the specialized knowledge of plants required.

In spite of the variations possible between shared and exclusive environmental knowledge in men and women daily life, women's roles in the spiritual aspects of local knowledge are often at least equivalent to, and occasionally more significant than, men's. The at-least-equal status of women is a reflection of the natural duality of the world many Asian community believe represent the balance between opposites that brings harmony (McNeely & Wachtel, 1990, p. 73). It also demonstrates the interconnections between the secular and the spiritual worlds, where many roles can be played by one individual. For example, the snake princess, whose annual performance of the King Cobra kissing ceremony to ensure the monsoon rains does not conflict with her other, more prosaic role, of farm worker (McNeely & Wachtel, 1990, p. 71). This example demonstrates the web of relationships between the individual, the community, the natural environment and the spiritual world supporting local environmental knowledge systems.

Spirituality pervades the vast majority of local approaches (McNeely & Wachtel, 1990; Bruun & Kalland, 1992; Knudtson & Suzuki, 1992; Uraivan, 1995; Choochat, 2000) and strongly contributes to local approach natural resource management and practice constructs. Often this spirituality is reflected in a sacred respect for the elements and natural features, where such features are seen as being or having a spirit life force. It is the respect for spirits (such as those of the rivers, rain, wind or forests) that encourages local practices to follow natural cycles. The Tai (Dai) people of south China and north Thailand, for example, believe water to be the origin of life and worship it accordingly. The cultural significance of Tai water understandings are such that "it shapes their perception of the environment as well as their settlement patterns" (Jianchu & Salas, 2003, p. 138). The interwoven nature of spirituality in Tai life can be seen in their calendar which includes water "ceremonies and rituals" (Jianchu & Salas, 2003, p. 139) as well as meteorological data. Further the management of their irrigation systems includes maintaining a "village spirit forest" (Jianchu & Salas, 2003, p. 139) where each catchment has a forest where everything, including the water sources, is sacred and to remain untouched.

The day to day operations of local environmental knowledge systems may be grounded in a local and practical context, but this does not preclude complementary global understandings of the world. Angkor Wat stands as testimony to an influential Kingdom driven by Hindu-Buddhist cosmology. This influence, and associated wealth, was gained through an intimate, positive understanding of overland flow that generated a simple, yet sophisticated flood-retreat agricultural production system (Stott, 1992, p. 55). That is, the rice surpluses behind the wealth came about because of willingness to work with natural cycles by harvesting overland flow as available and growing crops suited to long periods of inundation. At the same time the lands, the water source (ie rain), and indeed, anything related to protecting rice production were involved in a continuous cycle of political, cultural and spiritual rites and rituals to ensure the ongoing prosperity of the kingdom. Even the physical design of Ankgor Wat invokes the imagery of the mythical Mt Meru, and the Ocean of Infinity (Stott, 1992, p. 55; Jumsai, 1997, p. 21). There are many other examples of global perspectives in local approaches. What is common to the cosmological models is that the associated ethical and spiritual world views, often dismissed as irrelevant in the nominally impartial world of the scientific approach, are embedded in the natural resource management discourse and practices of the knowledge system (Johnson, 1992; Ford & Martinez, 2000; Berkes et al, 2000, p. 1259). These global understandings do have implications for the expansionary nature, or otherwise, of specific local approaches.

The preceding investigation shows local approaches be to multi-dimensional bodies of knowledge (Jianchu & Salas, 2003), incorporating practical and spiritual understandings of the local environment. The sense of multiple connections between people and the environment, created by the holistic nature of these knowledge systems (Johnson, 1992), encourages the associated communities to work with natural cycles. That is, local approaches are a

> "way of knowing based on concepts of the world as a reciprocal relationship between human beings, spirits and natural beings, all three constituting an inseparable unit and nurturing each other" (Jianchu & Salas, 2003, p. 134).

As the world is seen to be composed of inter-relationships the understandings of, and approaches to, overland flow would necessarily incorporate this same sentiment. Accordingly, local approaches tend to protect water sources, impeach water sources such as the monsoons and nurture water sources. The local approaches raised here tend to see all overland flow as useful, if not to humans, then to some other being or entity. This is not to say that these communities do not attempt to mitigate the extremes of natural cycles – very few communities do not seek to manipulate the water cycle in some way. It is that the manipulation of the local water cycle is not done only from a human perspective, with processes often built in to ensure non-human needs are also met. These features generally combine in a way that allows local knowledge communities to see overland flow as a significant source of water, worth protecting and using wisely.

Key Values

In addition to a value system that generally affords overland flow a positive role, there are two other values common to local knowledge systems that preclude the likelihood of a stormwater construct occurring. Both of these stand in stark contrast to the values of the scientific approach of controlled water environments and a reliance on commodification to account for the wide ranging uses of water. The first stems from the flexible and adaptable nature of local approaches, encouraging a willingness to work with unchannelled and uncontrolled water environments. The second value is that of community economies. That is, the nature of the economic system in local knowledge communities tends to adopt non-capitalist approaches to natural resources, rather than the capitalist approach preferred by the scientific approach.

Uncontrolled water environments

Local approaches reflect a degree of comfort with uncontrolled water environments not displayed by the scientific approach. For example, overland flow harvesting techniques found in local approaches often involve tapping into the flow stream (Agarwal & Narain, 1997, p. 25), In a community economy, "economic value is liberally distributed, not attached to certain activities and denied to others" (Gibson-Graham, 2005, p. 13). That is, social relationships are not subordinate to objective relationships. The contingent nature of relationships found in community economies (Gibson-Graham, 2005, p. 20) reflects the interdependence common to local environmental approaches, as in this situation helping with the harvesting, for example, has implicit economic value, as does contributing the seed. Being part of the team that looks after the weir, helping on others' rice paddies, or swapping chicken eggs for herbs are also recognized as economic activities. These contingent relationships extend to water uses and collection, as these activities are integral to the "identity, religious beliefs, ritual practices and daily engagements and concerns" (Whiteley & Masayesva, 1998, p. 12) of those involved in local approaches. These intertwined, symbiotic relationships prohibit the commodification of overland flow by not affording one portion of overland flow to have greater value than another. The diversity of human relationships with water, the willingness to work with uncontrolled water environments and the importance of respecting the spiritual forces inhabiting the environment combine to encourage local environmental knowledge systems to attach positive value to all overland flow. Given the number of uses for water, and ways to values it, it is unlikely that any water entering the local approach community water cycle would be disposed of without use. Not only would that be wasteful, it could mean missed spiritual, social, household or economic opportunities.

This chapter has shown how the common deeper values supporting local environmental knowledge systems, particularly working with uncontrolled water environments and embracing community economies, are integral to positive valuations of all overland flow and conservation focused management practices. The broad geographical nature of, and practical variations in, these knowledge systems are unsurprising, given a long-term focus on one place, sometimes with limited outside contact, different climate regions, resources and the myriad of competing social, political, environmental and economic priorities possible when groups of humans seek to use, manage and distribute those resources (Johnson, 1992; Foale, 2006). The next chapter uses *local wisdom* (ภูมิปัญญาท้องถิ่น), the generic name for the local environmental knowledge systems found in Thailand, to practically demonstrate how the process features and values raised in this chapter influence the overland flow understandings and management practices of a specific local environmental knowledge system.

Ch 4 Thai local wisdom: Not a wasted drop

> "To be able to drink from the water, you must look after the water. To be able to eat from the forest, you must look after the forest (ได้กินนำ ้ต้องรักษานำ ้ได้กินจากป่าต้องรักษาป่า)." *A local wisdom water use rule, to avoid angering water spirits. Choochat, 2000, p. 102.*

As noted in Chapter Three, in spite of their common features a key aspect of local environmental knowledge systems is the diversity of practices found. No one local approach is exactly the same as another. This chapter explores local environmental knowledge (LEK or local knowledge) systems more deeply by focusing on one version, Thailand's *local wisdom* (ภูมิปัญญาท้องถิ่น). Local wisdom overland flow understandings and management practices are articulated in terms of the characteristics in Chapter Three, particularly community economies and the willingness to work with unconfined water environments. It explores how local approach features and values combine in local wisdom to inhibit a stormwater construct. This allows a more solid understanding of the richness of these systems to be achieved, while reinforcing the role of controlled, commodified environments in constructing stormwater. The example of public irrigation systems (PIS) is provided to further explore local wisdom's overland flow management practices, not to stand as a comparison to urban stormwater systems of a 21st century, industrialized economy. A somewhat idealised version of local wisdom is presented here, with the complex reality of contemporary practice presented in the case study and Chapter Five.

The importance of water to Thai culture is shown by Jumsai's bold opening statement in *Naga: Cultural Origins in Siam and the West Pacific* (1997), where he claims:

> "Possibly no other region in the world possesses as many water symbols as East and South-East Asia. Particularly in Siam, whether it is in ritual, literature, folk

art, painting, sculpture, architecture, or city planning, a host of aquatic attributes underlies them all" (p. 1).

The cultural significance of water to Thai culture is also indicated by language. The *Thai-English Student's Dictionary* (Haas et al, 1964) has more than 100 discrete entries for *water* (น้ำ), excluding compound and usage examples. Many of the compounds and idioms offered describe emotions (eg sincerity น้ำใสใจจริง) or characteristics (thoughtfulness, willingness น้ำใจ), as well as various types of water.

An analysis of the Thai term for local wisdom (phumbanyaa thong tin ภูมิปัญญาท้องถิ่น) shows the importance of place, knowledge and learning. Usually found in compound words, phum (ภูมิ) translates to *place*, *earth*[2]. Banyaa (ปัญญา) means *wisdom, (acquired) knowledge; intelligence.* Together they form the compound phumbanyaa (ภูมิปัญญา): an acquired body of knowledge about a part or area of the earth. Thong (ท้อง) refers to an expanse, such as that of a field, water or the sky; or an area, of water or a road for example. Tin (ถิ่น) translates as *place*, *location*, *locality*, *domain* or *domicile*. As a compound word thongtin (ท้องถิ่น) means an *area*, *district*, *municipal area* or *locality.* These two words further compound to become phumbanyaa thongtin (ภูมิปัญญาท้องถิ่น), which can be defined as acquired body of knowledge used to live with the resources in your area. Or, more simply, local wisdom. This analysis shows local wisdom to be rooted in systematic knowledge and learning about a particular expanse of space, with the use of multiple words for space and place forming this compound reminiscent of the layered nature of local environmental knowledge.

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[2] All definitions provided come from the *Thai-English Student's Dictionary* (Haas et al, 1964); later translations of Thai quotes are my own.

Local wisdom is more than environmental knowledge regarding plants, animals, water management and food sources. It also includes understandings and knowledge about architecture, boat building, daily tools and objects, engineering, textiles, town planning and much more (Jumsai, 1997; Lorlowhakarn & Teth-utapak, 2003; Panin et al, 2004; Unknown, 2005). Environmental knowledge is one aspect of the overall body of knowledge known as local wisdom. As this paper deals primarily with environmental knowledge, the use of the term local wisdom refers to such knowledge, unless specified otherwise.

Process Features

As with both the scientific and local approaches generally, local wisdom has an empirical focus and seeks to measure and record what is observed (Choochat, 2000; Panin et al, 2004; Unknown, 2005). One of the more interesting local wisdom water measures is an annual rainfall measure that comfortably places the spiritual world with that of the human. This system, called "Naga giving water" (นาคให้น้ำ) (Jumsai, 1997, p. 24), places the Naga, a cosmic serpent strongly associated with water, on a scale of one through seven, with increments of one Naga. A one Naga year is considered good as only one Naga is drinking the available water. A seven Naga year is a dry year as the maximum number of Naga possible are drinking all the available water, leading to drought (ibid, p. 24). This Naga based measurement is particularly relevant to understanding local wisdom approaches to overland flow as it indicates these communities to be more concerned about drought than flooding. As it is not possible to have a no Naga year, then a one Naga year surely indicates significant overland flow events, possibly flooding. It seems feasible that a community concerned about drought would value all water sources positively.

Most local wisdom was transmitted orally, through rituals and practices. Although written records were kept following the introduction of the Thai writing system during the reign of King Ramkamhaeng (r. 1279-1298), much of the information written reflected the preoccupation of the political core with trade and taxation (Suarez, 1999). An exception is medicinal knowledge, such as herbs and remedies, which has a longer written history than most other aspects of local knowledge (Culhane-Pera, 1997). Recent rising interest in local wisdom has led to a flurry of written information about the diversity of practices and knowledge found in the various forms of Thai local wisdom.

Local wisdom categorizes water in a number of ways, with the classification used depending on the reason for classifying. For example, water is divided into three descriptive categories – fresh, brackish and salt. Fresh water is the category most directly used and provides transport, cultivation, consumption and food source (especially fish) services to riverine and off-river communities (Panin et al, 2004). The readiness of collected water for drinking is classified according to whether it has been boiled (น้ำสุข) or not (น้ำดิบ). Words for groundwater (น้ำบาดาล), floodwater (น้ำท่วม), dew (น้ำค้าง), bodily fluids (eg saliva น้ำลาย) are other examples showing the variety of local wisdom water classifications.

The most common forms of technology to capture and use overland flow are the networks of canal and dyke systems found throughout the country. These networks occur at a variety of scales, ranging from the sophisticated and extensive systems of Bangkok and other historical capitals (Shinawatra, 2002, p. n.d), to simply constructed systems of open troughs and ditches to direct excess overland flow away from settled areas into nearby agricultural fields or marshes. The PIS section of this chapter examines how the management of these networks reflects the overall principles of both local wisdom and the overarching local knowledge framework. Less complex than the canal technology is the widespread use of split bamboo stems to harvest rainwater from roofs, and earthen pots to store the collected water (Panin et al, 2004). Overland flow accumulated in ponds, swamps and marshes some distance from where it is to be used is generally reserved for drier than average periods. These water stores also provide food sources, aesthetic and spiritual amenity and transport infrastructure, subject to their temporal and spatial dimensions (Choochat, 2000). These simple, accessible water distributing technologies proved to be largely suitable to the capacity of the environment and the needs of the community.

Values

In contrast to the secularism of the scientific approach, spirituality is evident in local wisdom environmental management practices. Naga, the mystical water serpent noted earlier as a measure of annual rainfall, is a powerful example of this relationship. Naga's most important function is to bring rain (Sparkes, 2005, p. 36) and many of the ritual practices associated with this creature are used to simulate rainfall. These activities reinforce spiritual, community and environmental interconnections. Naga is also associated with fertility rituals and is a common symbol in architecture – particularly staircases, doorways and roofs – to represent the waters surrounding sacred Mount Meru from Hindu-Buddhist cosmology (Jumsai, 1997). That is, these practices "show how the villagers incorporate certain aspects of Buddhism as a legitimising force" (Sparkes, 2005, p. 177).

Not as powerful as Naga, but still very important, are the water spirits that inhabit every waterway. For example, every creek, stream and river has a "spirit that fattens the water" (ผีขุนน้ำ) (Choochat, 2000, p. 105), who is thought to create the water flow throughout the year. Ranked in order of importance, somewhat akin to the stream ordering systems of hydrology, the spirits of larger rivers are invariably more powerful than those of the tributaries or creeks. To show their "respect towards the spirits which support and protect the usefulness of the waterway" (Choochat, 2000, p. 105), villagers are careful to conserve those forests known to be the source of the water that the spirits live in. That is, protecting water and forestry sources are interchangeable natural resource management practices and spiritual acts. By generating, and adhering to, a list of prohibited forest activities, villagers believe it possible to avoid angering the spirits, as it is also believed any bother felt by them is felt by humans (Choochat, ibid).

Both men and women participate at least equally in the spiritual life of the community (Sparkes, 2005, p. 7), with women having significant roles in fertility rituals (McNeely & Wachtel, 1990, p. 73). They also share agricultural activities, but generally women do more of the daily household duties (McNeely & Wachtel, 1990, p. 145). This range of community roles gives women many streams into the community economy as these activities have economic, as well as practical or spiritual value. The role of community economies in promoting the capacity of a Thai community to be self-sufficient has been widely recognized by local wisdom researchers (Lorlowhakarn & Teth-uthapak, 2003, p. 1; Panin et al, 2004; Unknown, 2005).

Partly due to the different priorities of community economies, particularly a lack of emphasis on private property as compared to capitalist economies, and the place of spirituality, the interrelationships between people and the environment found in local wisdom allow for tolerance regarding natural cycles. This tolerance is reflected in local wisdom's comfort with uncontrolled water environments. As has been noted already in this chapter, Thai culture is well adjusted to the water flows of its tropical climes. Jumsai (1997) argues how the aquatic origins of Thai culture can be seen in a vast range of practices, including weaving (p. 60), the range of boat types (p. 52), architecture (practical and ornamental) (p. 77) and water's use in rituals (p. 30), for example. Thus local wisdom is a flexible responsive environmental knowledge system, including spiritual components to protect, or create, a way of living safely with the environment (Choochat, 2000). Living safely with the environment includes respecting overland flow so that always "in the rivers there are fish, in the paddies there is rice" (Ramkamhaeng Inscription of King Ramkhamhaeng r. 1239 - 1317).

Accepting water environments

It is clear the local wisdom idea of overland flow is something more than the scientific definition used in earlier chapters. More than excess rainfall running over the earth's surface, overland flow is seen as an integral part of the environmental, economic, spiritual and social system. As water flows from one part of the locality to another, all components of society and environment link forming, to those participating, a cohesive whole. With so many local wisdom practices revolving around water, be they spiritual or practical activities, environmental knowledge regarding water is critical to the meaning and practice of local wisdom.

This picture of overland flow shows some of the ways local wisdom is representative of local approaches. Also evident is that it is the combination of a community economy and local wisdom's willingness to work with relatively uncontrolled water environments that ultimately precludes the construction of a wastewater category, such as stormwater, in local approaches to overland flow. On one hand, the economic dynamic generated by a community economy in local wisdom means no economic gain can be had through valuing one water source by devaluing another. On the other hand, the acceptance of uncontrolled unchannelled water environments - as shown by elevated housing, agricultural practices such as wet rice production and socio-economic practices, such as floating markets (Jumsai, 1997) - while not eliminating discomfort or inconvenience to the community or individuals does show a recognition of the need to work with water, regardless of the conditions under which it arrives.

Public Irrigation Systems

Public irrigation systems (PIS, เหมืองฝาย) are discussed here to provide a specific example of local wisdom's systematic overland flow management practices. Although this discussion aids in showing the influence of the key features of both knowledge systems on the likelihood of a stormwater construct, it is not meant to be an inter-knowledge system comparison. Rather it looks at the complexity of the environmental, social, spiritual and economic interrelationships involved in local water approaches and how they combine to preclude the development of a stormwater construct.

These water management systems, reliant on excess overland flow, have developed in tandem with human settlements on most rivers in northern Thailand over hundreds of years (Uraivan, 1995, p. 13; Jianchu & Salas, 2003 p. 138). While demonstrating the resilience and adaptability of local wisdom, this time frame also indicates the depth of knowledge and skills contained in local communities. Uraivan defines public irrigation systems geographically as "that ecological unit within boundaries encompassing all that paddy land which is irrigated by one weir system" (1995, p. 18). Consistent with local approaches to technology, PIS technology relies on simple and locally accessible materials such as bamboo, stone and earth (Uraivan, 1995, p. 53).

More than geographical entities, PIS's are cooperative water management systems, based on long-standing mutual agreements articulating the

> "allocation, regulation and distribution of water according to schedules, maintenance and repairs, arranging ceremonies and rituals of worship and managing disputes over water among farmers" (Uraivan, 1995, p. 20).

Clearly, PIS are administrative structures bringing the main production systems of agriculture, and the water they depend on, into a socio-legal system (Uraivan, 1995, p. 53). The enduring success of these systems is largely a function of their adaptability; they are capable of changing to match changing social, environmental or economic circumstances to ensure community "autonomy in managing resources" (Uraivan, 1995, p. 44).

Table One shows how the principles of local wisdom's public irrigation systems reflect the broader values of local approaches in relation to overland flow (Uraivan, 1995, pp. 45-46), and gives an idea of the complexity of the interrelationships in local wisdom and, by extension, other local knowledge systems. Given space limitations, the following analysis focuses briefly on some interrelationships between the spiritual, the community economy and the water environment understandings of public irrigation systems to show how they reflect positive understandings of overland flow in local wisdom.

Table 1 Selected PIS principles and related local approach values.

PIS Principle	Related Local Approach Values
just allocation "Rules have been established specifying the labour and material contributions of each member in accordance with the area of paddy or other agricultural land."	spiritual contextual community economy shared gender roles practical and experiential
precedence, seniority "the sum total of their [pioneer farmers] continual investments...accumulated over many generations, is much greater than...who came later."	community economy practical/experiential contextual spiritual
balance individual interchanges "Equivalent right to have one's crops survive."	empirical water environment understandings contextual practical and experiential community economy
differentiating responsibilities according to ability "takes into consideration the capabilities of each."	community economy shared gender roles contextual practical/experiential

Following Uraivan, 1995, pp. 45-46.

The strong overlap of the significant local approach values with the public irrigation system principles is clear. The only value poorly represented in Table One is water environment understandings. This is because working with natural water cycles is built into public irrigation systems as "water is seen to be a structural foundation for the relationships so important in farming communities." (Uraivan, 1995, p. 18). Water conditions are integral to "the sense of common identity" (Uraivan, ibid) throughout the community and it is this relationship that is the foundation of the public irrigation system principles. These water management systems did not operate in hydrological isolation, with co-operation between communities up and down stream being common in the operating agreements (Urivan, 1995, p. 15; Jianchu & Salas, 2003, p. 108). This need to manage water collectively creates a sense of the interconnection between communities throughout the catchment, at a range of scales, which does not seem evident in the water environment understandings behind stormwater.

The pervasiveness of the community economy is particularly evident in Table One. The wide range of activities that carry economic value include, but are not limited to, physical labour, tending to the spirits' needs, providing seeds, tools or meals or making merit at the local temple (McNeely & Wachtel, 1990; Uraivan, 1995; Choochat, 2000). Not only individual activities, but the rotation of these activities throughout all sections of the community adds to the "sense of unity and cohesiveness" (Uraivan, 1995, p. 45) that builds and strengthens relationships. For example, ensuring canal and village based work are rotated allows not only for the just allocation and balance of individual interchanges (Uraivan, 1995, p. 45-46), but strengthens communal relationships as the physical, spiritual and emotional requirements for the work is widely appreciated.

The institutionalizing of spiritual duties in public irrigation systems maintenance agreements (Uraivan, 1995, p. 20) could provide no clearer indication of the significance of spirituality to local wisdom, and local approaches more generally. Contemporary state attempts to regulate these communities suggest impending ruptures not only to the spiritual practices but also to the economic valuations informing PIS practices. It is the combination of local technology, contingent relationships and a positive ethical framework that sustain public irrigation systems (Uraivan, 1995, p. 18).

Not a wasted drop

This brief investigation of local wisdom generally, and one management approach (PIS) in particular, exemplifies the broader local approach to overland flow environmental knowledge. Accordingly, it is possible to use this discussion to outline how the values of local approaches could converge to inhibit an overland flow construct akin to stormwater.

Given Thai communities are more concerned about drought, the conceptual basis of water understandings stand in stark contrast to the scientific approach basis of flooding fears. This significant difference approaching water environments sets the two knowledge systems on vastly divergent water management paths. Communities concerned about water scarcity would be more inclined to value every drop of overland flow, than those communities with flooding as a primary concern. At a practical level, the use of topology and locally sourced material, combined with high labour requirements meant many engineering/technological interventions into water environments were necessarily small scale. Only the largest, richest urban centres could afford to construct anything more than fundamentally necessary water infrastructure. That is, most water interventions were designed to take advantage of the water cycle, not manipulate it.

Being steeped in a community economy is an important impediment to a stormwater construct in local approaches. As economic exchanges are composed of primarily of non-capitalist activities and transactions, all communities members have an investment in the water and associated infrastructure, through their labour, material contributions or participation in spiritual rites, for example. This situation provides very limited opportunities for a group or individual to commandeer any portion of overland flow for their financial gain, as can happen in the scientific approach based communities.

The dominance of the community economy is evidence that water's importance in these communities is more than economic. Water is a vital source of spiritual and (inter)community reciprocal relationships. It is the basis of lifestyles and cosmological understandings. These relationships, practices and understandings developed to ensure continuous, relatively reliable water supply in the light of local hydrological conditions. Each of these reasons on their own have little in common with the stormwater construct of the scientific approach that causes overland flow dumped, unused, at the end of the catchment. All of them combined in one knowledge system means not a drop of overland flow is wasted.

Same same, but different[3]: A case study of the different approaches to overland flow through time in the ACT and Chonburi.

Designed as a stand alone section, this case study shows the clear influence different environmental knowledge systems have on the valuing and management of overland flow by focusing specifically on just one outcome of overland flow: wetlands. Contrasting the history of wetlands value and management through time in the Australian Capital Territory (ACT), Australia, using scientific environmental knowledge (SEK or the scientific approach), with those of local environmental knowledge (LEK or local the local approach) in Chonburi Province, Thailand, the no-use mentality of the scientific approach's stormwater construct is contrasted with local wisdom's multiuse approaches to overland flow. This case study also highlights that the management and practices of both knowledge systems are currently being challenged. The contrasting nature of these challenges, and responses to them, are explored in Chapter Five.

Couched in terms of the overarching knowledge systems, the roles and values attached to wetlands in both locations is told to some extent as historical narrative and includes a brief description of each location. Although the discussion is presented in terms of the features identified in the Tables Two and Three, economic practices and water environment understandings are given greater prominence, reflecting their greater influence.

Wetlands are in-stream features, temporally and spatially reliant on overland flow. The dominant feature of these marshy environments is the abundance of emerged and submerged plants, although there will be some clear water to accommodate flow variability. Other than assisting

[3] This saying is common 'Thinglish' used to describe things that appear similar, but have very different values and motives underlying them.

flood mitigation, wetlands also reduce pollutant loads, support biodiversity and promote in-stream health and recreational opportunities, while adding a pleasing aesthetic to the local area (Lawrence & Breen, 1998, p. 1). Local approaches have long taken advantage of these environmental processes while the scientific approach has been less confident in their efficacy.

The following tables briefly outline the characteristics of the scientific approach, the local approach and local wisdom, as outlined in Chapters One to Four, to provide an understanding of the key differences and similarities of the local and scientific approaches used in the broader research. Table Two contrasts those process features of each knowledge system that are representative of the process of knowledge production and application. Table Three indicates the values driving knowledge production and application. There is definitely some overlap as any process used represents a choice based on prioritizing competing values. Tabulating this information neither dismisses the many intersections nor interdependent relationships found between these characteristics. There is no suggests this is an exhaustive list.

The first obvious difference is that technology is placed in different tables, reflecting the different emphasis placed on technology in both systems. The scientific approach's reliance on technology, and its increasing complexity, is significant enough to be seen as a guiding value of knowledge system. That is, technological approaches are seen as an integral part of the conceptual and process components of the knowledge system. In local wisdom, technology is simply one of many tools available to manage overland flow.

Table 2 Process features of the scientific approach, the local approach and Thai local wisdom

Scientific Approach	Local Approaches	Thai Local Wisdom
Data sets - synchronic ie short time series over large study area; mathematically accurate	Data sets - diachronic ie long time series in one (small) locality; practical accuracy	diachronic data collected by users; practical accuracy
classifies	classifies	classifies
empirical; rationalist explanations	observation based; likely to offer (partially) spiritual explanations for phenomena	observation based; likely to offer (partially) spiritual explanations for phenomena
written word	oral, non written traditions	oral, non-written and written traditions
generalist knowledge tradition; theories abstract from context	practical and experiential knowledge; theories and practices contextual	practical and experiential knowledge; theories and practices contextual
N/A	use of local technologies	use of local technology and adapts other technologies as useful

Both knowledge systems are empirical and favour classification. Yet the mode of transmitting data, the nature of the data sets and the emphasis on accuracy within each knowledge system are different. The contrary nature of the data sets (ie synchronic verses diachronic sets), combined with the underlying values guiding each environmental knowledge system lead to very different presentations and use of the data collected and observations made. In the scientific approach, the broad area of study in synchronic sets reflects the theoretical and transcontextual nature of enquiry that tends to accompany global perspectives. Added to this heady mix is the notion of a right to control nature for human benefit. The end result is a relatively rigid environmental knowledge system, cautious in accepting alternative perspectives, knowledges and practices.

Table 3 Values of the scientific approach, the local approach and Thai local wisdom

Scientific Approach	Local Approaches	Thai Local Wisdom
technological reliance – practically and conceptually	N/A	N/A
portrayed as impartial and rational but often ends up inflexible and rigid	flexible and adaptable with diverse practices and structures	flexible and adaptable, adopts aspects of other knowledge systems
global perspectives	local perspectives	local perspectives
secular	spiritual	spiritual
masculine dominance of public roles	shared public roles	shared public roles
right to control nature ie water environments actively contained	work with natural cycles ie uncontrolled/loosely defined water environments	work with natural cycles ie uncontrolled/loosely defined water environments
capitalist commodification of nature	community economy	community economy

In contrast, local wisdom is a knowledge system founded on detailed data generated over the long term and values the practical application of knowledge, skills and technology to satisfy local environmental priorities. It can be further portrayed as a flexible knowledge system, willing to work with environmental cycles while accommodating human, spiritual and environmental needs. In addition to these compelling combinations, there are two further significant factors of the knowledge systems affecting the understanding and management of overland flow of each. These factors are the different priorities given to capitalist transactions and the (un)willingness to work with uncontrolled, un-channelled water environments.

Chapter Two argued capitalist commodification values and desire for controlled water environments inherent in the scientific approach makes stormwater an almost inevitable product of the scientific approach. This is because as capitalist profit is sought from some overland flow, other (waste) categories of overland flow are required to ensure the success of the commodified water. This conceptual and physical division of water was made possible by the right to control the physical environment embedded in the approach, combined with technological interventions and a wastewater friendly landscape of concrete drains and channels was created. In this context wetlands were seen to slow the flow of stormwater, thus reducing the efficiency of the system. Consequently many were drained, as the channels feeding them were concreted and straightened, and became a part of the stormwater channel. As stormwater infrastructure expands, generally speaking the surface area of wetlands decreases (Walsh et al, 2004, p. 7).

However in local wisdom the willingness to work with uncontrolled water environments combined with a community economy, precludes a stormwater construct as one portion of overland flow is not played off against another. All water is useful, with water of different qualities playing different roles, never no role. The use of wetlands to store and treat water is integral to local wisdom overland flow management and practices. Wetlands also play important food harvesting, recreational and spiritual roles.

Wetlands and overland flow in the Australian Capital Territory

The ACT is a planned national capital of 2 358 km^2, with just over 77 km^2 of this being surface water, consisting of the urban centre of Canberra and a few small villages. Between the four conservation areas (Namadgi National Park, Tidbinbilla Nature Reserve, the Canberra Nature Park and the Murrumbidgee River corridor) and multiple forestry plantations, approximately two-thirds of the ACT is unavailable for urban development. Relatively even annual rainfall distribution (Mitchell, Mein & McMahon, 1999, p. 16) means a fairly constant load on the urban stormwater system.

Prior to European settlement in the 1820s the area was part of Ngunnawal country and its water bodies, including wetlands, were used according to the water management practices of the local environmental knowledge system of the Ngunnawal people. The impact on regional wetlands is considered likely to be minimal due to a low population and the varying lengths of time spent in the different parts of Ngunnawal country (Flood, 1980). Between the initial European settlement of the region and the establishment of the ACT in 1913, the regional waters, including one of the case study's examples, Sullivan's Creek, were sites of conflict between the established indigenous uses and new pastoral ones, particularly during the extended dry periods in 1826 – 28 and the early 1830s. During the first of these dry periods the indigenous community was able to retreat to places as yet unexplored by the settlers. This option was not as readily available in the 1830s due to the increased European population density and expanding settler boundaries in the finite Ngunnawal lands (Avery, 1994).

As Canberra grew into an urban centre, settler practices dominated, strongly influenced as they were by the waxing values of the scientific system. This influence saw the construction, physically and conceptually, of systems to capture overland flow and convert it to the waste water product stormwater (Stanhope, 2006). Important creeks feeding the Murrumbidgee River, such as Yarralumla Creek in the southern part of the city and Sullivan's Creek in the north, were straightened and concreted in large sections, leading to the loss of wetlands along these channels. The conventional channel and kerb overland flow harvesting technologies of suburban Canberra were then plumbed into the now named stormwater drains with the water, now known as stormwater, being directed into the Murrumbidgee River. This water receives only limited treatment, primarily focusing on removing gross pollutants such as trolleys, big bits of wood, plastic and metals and other urban rubbish. One result of the allegedly flood mitigating stormwater system is more frequent flash flooding, where peak water volume is higher and flow velocity faster (Walsh et al, 2004, p.

9) than prior to the physical changes made to the system by the scientific approach understandings of overland flow.

The current extended period of low annual rainfall has forced local residents and public authorities to consider changes in stormwater management practices, to the point where stormwater harvesting became an issue in the 2007 Commonwealth election (Rudd plan. 2007, Nov. 29, ABC on-line). One of the responses by the scientific approach to these challenges has been to focus on wetlands for stormwater harvesting and treatment, often in the context of water sensitive urban design (WSUD), to reduce demand on reticulated supply. WSUD is briefly explored in Chapter Five.

Yarralumla Creek provides a good example to track this history of changing understandings of overland flow and wetlands. This creek was subject to the full force of the scientific approach's overland flow understandings and management (ie stormwater). Previous wetlands were drained and the resultant issues of more dangerous flows are indicated by the warning signs, discouraging playing in what was once a creek, along the channel. In late 2006, as part of the larger Canberra Integrated Urban Waterways Project, a significant rehabilitation of Yarralumla Creek was announced (Turnbull, 2006). The link with a large housing development (pers. com., Foskey, 16/05/07), was not mentioned in the media. The stated purpose of this rehabilitation is to restore the creek and wetlands in an effort to improve stormwater quality so it can be harvested for public irrigation, which in turn reduces the demand on reticulated supply (Stanhope, 2006). That is, a step away from the dominance of scientific approach has been taken. As will be argued more assertively later in this thesis, it is not as big a step as it appears at first glance.

Sullivan's Creek has already benefited from changes to conventional stormwater understandings and practices. As a member and one time coordinator of the Australian National University WaterWatch group, multivalue/multipurpose roles of wetlands is not matched by a similar appreciation of a community economy (which may explain fenced wetlands). The challenges that led to stormwater being "reevaltuated" (Mitchell et al 1999, p. 4) is discussed further in Chapter Five.

Wetlands and overland flow in Chonburi

Located on Thailand's Eastern Seaboard, Chonburi province is reliant on water for almost every aspect of life. The name literally means "water town" and parts of the historical city sat on stilts beside docks above the large tidal zone (Pongsapich, Hafner, Veeravongs & Sirisumbhand, 1979). The contemporary town, capital of the same named province, is now crammed between the landward side of the intertidal zone and the main highway heading east from Bangkok. Prior to industrialization, Chonburi was an agricultural/fishing society with many activities related to the ocean including fishing, fish sauce, dried fish and squid. Rice farming and mixed small scale agriculture remained important activities (Pongsapich et al, 1979). The pace of life was tempered to the ebb and flow of the tides, with its focus more on human-water than human-land relationships (Jumsai, 1997). The tropical climate and low lying land encourage temporally variable wetlands of various sizes. These wetlands are vital sources of food and water and many have spiritual significance. Given Chonburi province's coastline, many wetlands are mangrove environments.

Existing since the Ayutthaya Period (1350 - 1767), Chonburi's standing in Thai administrative ranking increased slightly in the reign of Rama 1 (King Yodfah Chulaloke r. 1782 – 1809, founder of the Chakri dynasty) following the region's support for the previous King in reclaiming Siam from Burma (Pongsapich et al, 1979). The region is now more integrated into both Thai and global economic aspirations than other areas of the Kingdom. This significance is demonstrated by the emphasis in national development programs for the industrialization of this part of the country (Pongsapich et al, 1979; Thawthong, 2001). In many ways, the eastern seaboard represents the globalized developed economy to which the Thai political and economic elite aspire. Chonburi, the largest province in the region, is integral to Thailand's transition from an agricultural society ruled by an absolute monarch to an industrial society governed by State institutions.

Nineteenth century maps of the Bay of Thailand suggest the Chonburi coast line was heavily forested to the shoreline, including mangroves (Phasuk & Stott, 2004, p. 148). A 1986 topographical map of the Chonburi coastline shows significant mangrove stands remained, as do satellite images from 1991 (ibid, p. 151). These mangroves, and other wetlands in the region, played vital roles as a source of food and materials and work and worship sites. Many of these coastal areas are now cleared of mangroves. The loss of wetlands on a large scale in Chonburi is most obvious on the coastline near Chonburi town and other large coastal towns of the province such as Pattaya and Sattahip, where housing estates, tourist resorts and industry have replaced them.

The national development plans adopted after World War II mark the contemporary concerted and organized introduction of the scientific approach (Thawthong, 2001). Although the introduction of stormwater infrastructure has been patchy, it has still led to the loss of wetlands. For example, Burapha University in Bang Saen has a series of lakes and wetlands throughout the campus. Not only do they largely capture the overland flow during the wet season, they also provide important spiritual sustenance and general amenity to staff and students. They are used for studying and courting and one wetland in particular has strong spiritual significance for students seeking good results. The university was plumbed and connected to the local stormwater system in 1997/98. The system was installed with limited disruption to the wetlands. The number of buildings and people on the campus has grown substantially in the last 10 years and the lakes and wetlands are gradually being filled in to accommodate the associated land demand, increasing the load on the stormwater infrastructure. A few years ago one of the wetlands was converted into a sealed surface parking lot and, in spite of the stormwater compete with another environmental knowledge system, as it has to do with local wisdom in Chonburi.

A similarity shown by this case study is that both knowledge systems' overland flow understandings are being challenged. And that both systems' are responding to the challenges. The nature of the challenges, and response, however, are different. In Thailand, local wisdom is responding to the demands of the scientific approach. In approximately 75 years, Chonburi has gone from being reliant on local wisdom understandings and management of wetlands to a scientific approach motivated removal of them. This followed with attempts to replace them with non-local versions of wetlands to manage the pollution of industrialization and urbanization associated with their removal. The cost has been more than environmental as local wisdom and technologies have also been removed, with limited knowledge of the scientific approach being provided to match its increasing use. Thai local wisdom is a local knowledge system being challenged by the colonizing tendencies of the scientific approach. The Chonburi example shows how the introduction of scientific environmental knowledge has changed the valuation and management of wetlands locally, such that it now largely mimics those of conventional stormwater drainage systems. Unfortunately the incomplete and inadequate knowledge of stormwater systems among everyday people means there is a higher likelihood of the system being used inappropriately.

The challenges to the scientific approach, however, are primarily internal. The positive change in the valuation of wetlands by the scientific approach has not come through the acceptance of an external knowledge source, but through a number of internal challenges to the longstanding knowledge system. The case study has identified community, industry and climate driven challenges to the sustainability of the stormwater construct. The reality is that these challenges strike at the core of the scientific approach as they force a questioning of values, such as the unencumbered right to control the physical environment for human convenience and a desire for controlled water environments.

Accepting that the knowledge in all knowledge systems is constantly changing, the nature of the current change in both systems appears more radical and deep-seated than such changes often are. This is because it is fundamental values, not simply process features, which are being challenged. These challenges not only show the fluidity of knowledge systems but provide an opportunity to critically examine their basis. In neither knowledge system are the challenges being ignored, with vigorous responses and counter responses in more than wetlands management, occurring in both Thailand and Australia. The next chapter investigates in more detail the nature of the challenges, and responses, to this current phase of rapid change.

Ch 5 Fluid knowledge systems

> "...The importance is we must have water to drink, use and cultivate [sic] life is here. If there is water, we can survive. If there is no electricity we also can survive. But if there is electricity but no water, we cannot survive."
> King Bhumiphon, 1996

This chapter critically investigates the case study's key finding that both the environmental knowledge systems explored are under challenge. Starting with the challenges to Thai local wisdom's overland flow understandings and management, the contrasting nature of the challenges to the scientific understanding and practices toward overland flow are also investigated. The associated exploration of the responses to these challenges shows not only the potential of both knowledge systems to adapt but also that challenges and responses occur across all scales of each community. This chapter also shows that now is an opportune time to effect meaningful changes in the way overland flow is valued and managed within the scientific approach, with many of its proponents and practitioners already seeking alternative overland flow management policies and practices (Lawrence & Breen, 1998: Mitchell et al 1999; Lloyd et al, 2002; Walsh et al, 2004). These challenges present an opportunity to adopt some of the practices and embedded values of local environmental knowledge systems. It is possible such an adoption could cement the transformation of stormwater from a waste product rushed to the end of the catchment to a meaningful supply of water throughout the catchment.

Challenges to local wisdom, and the responses, in Thailand

The challenges to the place of local wisdom in Thai society are primarily external. This can be largely explained in terms of industrialization and the colonizing tendencies of the scientific approach, including its reliance on technology. Industrialization, although beyond the scope of this research, is influential in a water management context due to its high demands for water of varying quality. Once a community begins to change its level of industrialization, water management practices need to be reviewed, including those applicable to overland flow, to ensure all (human and non-human) demands for water can be met. Thailand's rapid industrialization, especially in the Bangkok and Eastern Seaboard regions, has already had serious implications for both ground and surface water supplies (Chulalongkorn University, 2002). In spite of the limited discussion regarding industrialization in this paper, its significance to overland flow management practices remains an important background factor. The responses to these challenges have occurred across all levels and sectors of the Thai community and have largely centred on retaining and recording the various aspects of local wisdom. Different motives and priorities have led to conflict and an apparent strengthening in the validity and use of local wisdom.

SEK as colonizer

The colonizing tendencies of the scientific approach were noted in the case study. Briefly, these tendencies are encouraged by the transcontextual and utilitarian approach of this knowledge system, combined with commodification and the willingness to control nature. The case study showed how the environmental effects of this combination caused a reduction in wetland surface area and provision of environmental services as the use of conventional stormwater drainage increased. After changing the environment to suit industrial needs, the next step in this process of environmental colonization is to implement SEK-friendly remedial packages to manage the environmental consequences of those changes. The "one size fits all" colonizing approach common to both industrialization and remediation has created a number of challenges for local wisdom.

A significant challenge to local wisdom was the transplantation of the scientific approach to water management practices and technology into the Thai knowledge and physical environments. The problematic nature of taking a water management system (concepts and technology) of one knowledge system from one location and transplanting it in another into the periphery of the nation, Standard Thai language has increasingly become influential, at the expense of local dialects. As the scientific approach is increasingly used in Thailand, English is becoming an important language of communication. A significant consequence of the increased use English is that that concepts of the scientific approach influence Thai environmental thinking, at the expense of local environmental knowledge and languages. The co-option of naam laak into Thai technical language is one example of how scientific approach classifications can reflect English language structures and logic. Culture, languages and biodiversity are interwoven. As more Thai's use Standard Thai or English, the use of minority languages and dialects declines and so too the opportunities to access the gamut of local wisdom. Without knowing the linguistic terms for classification systems, for example, it is difficult to access environmental knowledge of local approaches (Jianchu & Salas, 2003, p. 135).

From a broader perspective, the loss of local wisdom has led to a loss of community pride. Some have argued this is a deliberate move on the part of the scientific approach as it seeks to "colonize" (Alvares, 1992, p. 228) the non-SEK world, in part by devaluing local knowledge systems. The use of expatriate elites in the scientific approach's geographical periphery is often effective in introducing the scientific approach in local knowledge communities by highlighting the knowledge and technology that comes with the scientific approach while making local communities feel inadequate (Winichakul, 1994, p. 60; Jianchu & Salas, 2003, p. 133) for wanting to retain their knowledge heritage. This loss of pride in local knowledge is indicated by the willingness of Thai authorities to adopt the scientific environmental system's version of wetlands for stormwater management, in spite of the long history of alternative wetlands practices in local wisdom. The loss of local wisdom and the parallel lack of deep knowledge about the scientific approach have created a situation where Thai's are increasingly more dependent on unfamiliar outside knowledge and experts for their water security.

Community responses to the challenges posed by the scientific approach have been varied. Some have embraced the OTOP scheme and changes to PIS management. Others have contested the role of the scientific approach, particularly in water management policies such central regulation of the management and operations of public irrigation systems or promoting large dam projects due to impacts on river flow, habitat and fisheries (Friend, 2007). One of the most famous community challenges to the scientific approach's dominance was over a nationally and internationally supported dam on the Mun River. The protest culminated in hundreds of thousands of people camping in Sanam Luang, a known Bangkok landmark for petitioning the King's favour, for over 100 days. It became known as the Village of the Poor. Their pressure ultimately forced an ungainly compromise that continues to cause contention to this day (Kan-Onsri, 2004). The Village of the Poor is a dramatic example of citizen's responses to the challenges presented to local wisdom by the application of the scientific approach's water management plans of government and international development agencies. These plans often conflict with how water has been managed historically and protests have become a common responses of the locals affected.

The Village of the Poor protest ignited local communities desire to record, use, promote and add to local wisdom, and academics to record and investigate local wisdom practices. This has led to a surge of research called Villagers' (or Barn Thai) research (วิจัยบ้านไทย), where locals and researchers investigate important environmental matters, as defined by the locals. The Village of the Poor has done research of this nature on the return of Mun river ecology and local peoples livelihoods since the dam gates opened in 2001 (SEARIN, 2004). Villagers' research shows an organized and committed resistance to the scientific approach by formally recording and to some extent, creating, local wisdom. Although its existence is almost entirely a response to the colonizing influence of the scientific approach, Villagers' research is likely to prove valuable environmental research, given the depth and breadth of community participation, and knowledge, possible in local approaches (McNeely & Wachtel, 1990; Johnson, 1992).

Villagers' research encourages the use of local languages for field work, though the results are usually published in standard Thai or English. Local languages are used in cases where no appropriate Thai word exists. As well as investigating handicrafts, food production and architecture, this research genre has a definite emphasis on river ecology and livelihoods. For example, the Villagers' research in Chiang Khong has documented the range of ecosystems that rely on the annual variation of water levels of the Mekong (SEARIN & Culture Conservation Network in the Mekong-Lanna Basin, 2004). This variation in water levels is a direct function of the amount of overland flow that is able to reach the receiving water bodies forming the Mekong river system and the villagers were seeking to show the impact of river regulation on these ecosystems and their livelihoods.

The Village of the Poor reminds us of the interrelationships between individuals inherent in local wisdom, as many individuals with mutual concerns and values were required to make The Village of the Poor a successful campaign. It is at the level of the individual were the use local wisdom overland flow understandings and practices are still commonly seen. For example, the collection of rainwater around the house, and boiling it before use, (pers. comm., 21/4/07), is a long practiced local wisdom use of overland flow. In 2007 this practice not only reflects an awareness of the multiple uses of overland flow, it also reduces the demand on stormwater infrastructure. Or the use of "new" local wisdom (Panin et al, 2004, p. 40), such as chickens farmed over fish ponds, reflects the historical willingness of local wisdom to adapt new technology and ideas as a viable place for it is found. The on-going application of local wisdom in individual lives suggests that the scientific approach understandings and approaches do not yet have widespread acceptance in Thailand, in spite of the seeming widespread acceptance it enjoys in the techno-political classes.

Colonization of local wisdom overland flow understandings and management by the scientific approach has also challenged the sacred connection to water (James, 2006, p. 88), a key value of local wisdom. While water remains central to key rituals at all levels of the community across the nation, over the last 15 years of concerted industrialization, the attitude to water *feels* different. Certainly the volume of water supplied for secular activities has increased (Thai Provincial Water Authority, 2007), as is usual with increasing levels of industrialization (Strang, 2004, p. 7). That stormwater in Thailand is not seen as having a spirit (pers. comm., April 2007), protective or otherwise, as most other water sources do, indicates that Thais recognize the scientific approach has no obvious link to anything spiritual. This is similar to the sentiment expressed in the AP Lands regarding tap water. Because tap water is seen as "white-fella dreaming" (James, 2006, p. 102), is it not sacred and can therefore be used less sparingly than sacred water. This observation leads to another. If a portion of water is not sacred, then one of the key factors generating respect for overland flow is lost. There is no longer a sense of negative consequences of inappropriate actions or needing to share the water with non-human elements.

This feeling of a changing sacred connection is best expressed by the markedly changed nature of the Thai New Year celebration Songkran. Flower scented water used to be gently flicked from small hand bowls onto a small part of the body of respected elders such as parents and monks. Water's ritual role as a purifier is so significant that even with the dry season water scarcity at this time of year its use, as judicious as it was, was required for the celebrations to be culturally coherent. Nowadays water is liberally sprayed around using, for example, large toy water guns or large buckets of water with siphons to shoot jets of water. Every year the rampant use of water and associated exuberant behaviour is a point of public debate, as it is disproportionately at odds with the heritage of the celebration. A sign is erected on the main road by the local council during the well established and patronized Songkran celebrations in Bang Saen reading, “Together we can protect Thai customs. Be polite during the days of Songkran.” This is a gentle, if disregarded, reminder to participants to be less aggressive in their water play. This example of Songkran as a reflection of changing Thai values toward water indicates not just the increase in water consumption that comes with the adoption of the scientific approach overland flow management practices. It also shows the influence of technology and commodification (the purchase of mass produced water guns for example) in contributing to the different *feel* to water, where there is not the same care and respect for water once evident in local wisdom.

Role of Thai Monarchy and State

The roles of the Thai monarchy and government in establishing the place of the scientific approach in Thailand is complicated. Sometimes they reflect a reaction to, rather than an encouragement of, the scientific approach’s place in Thai society. Either way it is appropriate to regard the role of the Monarchy and state in enabling the extensive role of the scientific approach in Thailand as an external challenge to the place of local wisdom. Before attempting to unravel these complexities it is important to briefly outline the complicated relationship between the monarchy and the government controlled state institutions. The following short summary of Thai modern history only hints at the tensions between traditionalists, modernists and the military. An absolute monarchy till 1932, the current King (Rama IX 1946-) wields more power than common in European constitutional monarchies. The period between 1932 and the rising influence of Rama IX is marked by coups, counter-coups, revolutions and authoritarian governments. Initially a pawn in successive authoritarian governments’ propaganda, the on-going political instability has resulted in a heightened sense of the moral authority of Rama IX. This authority was demonstrated in the 1992 political crisis when the de facto power of the monarchy outweighed the de jure power of the government, forcing a change in government. Many Kings, under both absolute and constitutional monarchy systems, have played important roles in the introduction and application of the scientific approach.

As mentioned in the case study, the inclusion of aspects of outside knowledge systems is not new to Thai society, for example King Mongkut's (Rama IV r. 1851-1868) simultaneous practices of spiritual and scientific discourses. A monk for over 25 years before ascending the throne, Rama IV resolved conflicts between Buddhism and western European science by "promoting an orthodox practice of Buddhism that eschewed belief in magic and the supernatural" (Byrne, 2007, p. 8). Thus the involvement of the monarchy, and later the state, in the colonizing tendencies of the scientific approach was established. Also established at this time was the role of the expatriate community in encouraging the introduction of the new knowledge, in part by devaluing local wisdom (Alvares, 1992; Byrne, 2007).

Although the monarchy's role in the influence of the scientific approach in Thai society is significant, in some ways it is a reflection of attempts to manage, rather than encourage, the colonizing tendencies of this knowledge system. This strategy has had some success in Thai political history (Winichakul, 1994). Certainly many of the responses at scales smaller than those of national priorities have been about limiting, or rejecting, the role of scientific environmental approaches in Thailand. Villagers' Research (วิจัยบ้านไทย) represents such a response.

The on-going influence of the monarchy in attempts to manage the colonizing influence of the scientific approach has continued in King Bhumiphon's reign (Rama IX r. 1946-). The contradictory roles of Rama IX in Thai overland flow understandings and management is shown by his pronouncements ranging in support of the scientific approach to asking Thai's to adopt a more local approach to their resource use. Early in his reign he was particularly interested in the flood mitigation and irrigation understandings and practices of the scientific approach (Maiklad, 1996).

Over the years he has moved to incorporate elements of both local wisdom and the scientific approach in his water projects. For example, there have been Royal Projects regarding the use of constructed wetlands for water quality management (Maiklad, 1996). More recently, his New Theory (ทฤษฎีใหม่), and its sibling the Self-sufficiency Economy, present an economic and social system grounded in community self-sufficiency, spiritual, human and environmental interrelationships and the importance of water (Pootrakool, 2006).

The New Theory is a contemporary articulation of local wisdom's reliance on a practical application and adaptation of local resources and knowledge. Water harvesting and multiuse management are key components of the New Theory. For example, the New Theory advocates one-third of a farmer's land being allocated to water storage, be it ponds, rice fields or household stores. Further, most water stores are to have more than one use, be it rice in fields or fish in ponds, with the total surface area to be distributed throughout the property in a number of sites, not one large water storage site (Office of the Royal Development Projects Board, 1996, p. 27).

The Thai state has had an important role in promoting the scientific approach (Maiklad, 1996), with successive Thai governments seeking to change Thai cultural and social characteristics to help integrate the scientific approach more widely throughout society (Lorlowhakarn & Teth-uthapak, 2003, p. 231). These attempts range from the National Development Plans to an emphasis in education and training on scientific approaches and linking national goals with personal behaviours (Lorlowhakarn & Teth-uthapak, 2003, p. 8). The end result is that this active state role has led to a lessening of local wisdom's influence, to the advantage of the scientific approach, as the state seeks to achieve its economic and industrial development goals.

Economic and Industrial Development

The scientific approach's paradigms are clearly seen in the decision-making processes of national and international agencies driving development activities in Thailand (Johnson, 1992, Arriens et al, 1996; Jianchu & Salas, 2003) and are increasingly being applied to public irrigation systems (PIS) (Uraivan, 1995, p. 22). This interest in what are local wisdom forms of water management represents one of the few times the state takes an active interest in local wisdom practices. The links between the public irrigation community and the wider community, due to their formalized nature, as outlined in Chapter Four, allows for some political permeability between state and local structures. Leaders of public irrigation communities may move into other areas of public life or, as is currently the case, the state may take advantage of its connections in the public irrigation community, seeking influence over water management (Uraivan, 1995, p. 45). Current state influences aim to have these systems operate according to the priorities of the scientific approach, including standardized management practices (Uraivan, 1995). One cannot help but wonder if the changes from these influences might go the way of many changes brought to the region by Indian water experts and technology around the tenth century A.D.; that is, being discarded by locals as active political support wanes (McNeely & Wachtel, 1990, p. 308-309).

There have been other impetus to the state's conditional acknowledgement of local wisdom. Supragovernment agencies' declarations, including the United Nations and Mekong River Commission, and the previous so-called People's Constitution had clauses specifically acknowledging local wisdom/local approaches and calling for its use in national development. Additionally, the Thaksin government (2001-2007) instituted the OTOP program mentioned previously. In this program each local council (tambon) concentrates on a specific, and unique, form of local wisdom suitable for export. This has led to communities focusing on one aspect of knowledge, be it dried bananas, orchid presentation or textiles, to the extent that other forms of knowledge are neglected. It also draws the local economy more into global capitalist economic transactions, reducing the reliance on community economies long part of the mutually beneficial interrelationships of local wisdom.

Although the challenges to local wisdom overland flow understandings and practices are largely external, stemming from the colonizing tendencies of the scientific approach, the openness of local wisdom, as shown by elite attempts to accommodate aspects of this knowledge system, contributed to the relative ease and speed of its penetration into Thai society. It has also been shown that the responses have occurred at all levels of Thai society, with even supragovernment structures such as the Mekong River Commission and United Nations officially desirous of a resurgence in local environmental approaches. However, at different scales of governance and activity, different priorities and focuses prevail. This has, on occasion, led to overt conflict about which knowledge system should be the framework for environmental practices in the Kingdom, and which the filler. A similar, but at this stage far less muted, conflict is occurring in Australia, as its overwhelming use of the overland flow management practices of the scientific approach are also being challenged.

Challenges to SEK, and responses, in Australia

In contrast to local wisdom, the challenges to the scientific approach overland flow understandings and practices are primarily internal. As already noted, there has been a quietly growing concern about waste water in the scientific approach, leading to an evolving critique of the stormwater construct, revolving around the no-use approach to the water and its increasing pollution loads. However it was not until the current extended dry period that more widespread attention has been paid to the growing body of knowledge, and practice, that makes more, and more sensible, use of stormwater. As with local wisdom experience in Thailand, the response to these epistemological challenges has occurred across every scale of the ACT community. However, in spite of the responses of the scientific approach, including moving toward multiuse understandings of overland flow, some responses still embrace the values of commodification and control of water environments.

Role of Academia, Industry & the State

Academics and researchers have played an important role in challenging the well-established stormwater construct. The private sector has also played a significant role in developing and introducing new approaches to stormwater management. As already noted, research interest has focused mainly on pollution and flow management. Currently small scale urban schemes are proving the most effective in challenging conventional stormwater management, due to perceptions on the part of researchers and consumers of its higher water quality than other wastewater (Mitchell et al 1999; Po et al, 2005). However, their effectiveness is limited by the "variable pattern and quality of rainfall" (Mitchell et al 1999, p. 9). Industry inspired stormwater harvesting techniques has come mainly from a need for large quantities of cheap but not necessarily potable, water. For example, the Parafields project in South Australia harvests a minimum of 1 110 ML of stormwater per year which is stored in aquifers. The volume stored is similar to the annual requirements of the wool processing company that went into partnership with the local council on this project (Salisbury City Council, 2003).

Water sensitive urban design (WSUD) is an integrated approach to urban design. A significant focus of this design approach is dedicated to mitigating the negative hydrological impacts of conventional stormwater management while providing alternative, non-potable, water supplies (Lloyd et al, 2002, p. 2). WSUD represents a move toward local approaches understandings of overland flow, as more water is incorporated into the natural landscape, rather than being confined to concrete spaces. That is, there is less effort to control natural processes and more intent to work with natural hydrological cycles. WSUD further reflects local approaches as best practice dictates no two projects can be exactly the same with every project being designed around site specific factors (Lloyd et al, 2002, p. 10). WSUD also represents an increased appreciation, on the part of the scientific approach, of the multiple uses and values that are possible to ascribe to overland flow.

The state's endorsement of WSUD is indicated by the range of government departments advocating it, including establishing guidelines and collecting information of principles and designs (Fletcher, Deletic & Hatt, 2004). Outside of support for WSUD and stormwater harvesting projects on a case by case basis, state/water manager solutions have mainly emphasized regulating individual behaviour, for example restrictions on outdoor water use and campaigns to encourage shorter showers and fixing leaking taps, to reduce the demand on reticulated supply. While reducing demand on reticulated supply has a negligible effect on the stormwater construct, the support of these agencies for WSUD practices such as wetlands for stormwater do influence public perceptions of stormwater.

In spite of its similarity to the 'use it where it falls' philosophy of local approaches, WSUD remains connected to the key scientific approach value of commodification. The Victorian Stormwater Committee (1999) makes no attempt to hide this connection when it identifies one of the key WSUD principles as adding value to development properties, while minimizing the cost of drainage infrastructure (p. n.d.). Also represented in WSUD is the significant role of technology. The locating of wetlands for development purposes, rather than in response to environmental indicators shows how technological capacity can outweigh environmental knowledge (pers. comm., Foskey, 16/05/07).

The increasing acceptance of WSUD shows these intellectual and practical challenges to the stormwater construct have enjoyed some success in shifting the wastewater discourse. However, these intellectual challenges were proving unable to provide the impetus for the major change in understandings required to mitigate the worst excesses of the stormwater construct. In spite of the positive examples of intellectual and practical challenges, it was not until the climatic challenge of the current extended period of lower than average rainfall that the missing impetus for a significant change in the understanding and management of stormwater in the ACT was provided. A series of seven Naga years forced a more widespread reassessment of current practices than many years of research.

The locals

Interestingly, as water restrictions have become increasingly comprehensive and the ACT government seeks technical and infrastructure solutions to water scarcity (ACT Government, 2004), at the community and individual/household level there has been a move toward solutions reminiscent of the local approach. The case study showed community driven changes in stormwater management and practices in the David St. Wetland example. The increasing use of rainwater tanks is a household/individual response to concerns about wasted overland flow rushing down stormwater pipes. The rebates now widely offered by governments on rainwater tanks were not instituted to increase tank uptake rates, but because of community tank uptake rates. This is one example of how individuals seeking multiple uses for overland flow, in opposition to the stormwater construct, are leading the state to do the same.

The increasing use of local approaches within the community and by individuals demonstrates the failure of the stormwater construct as multiple uses are increasingly sought by water users. This indicates that the scientific approach's pre-eminence in the ACT is being challenged by values of the local approach in the practices of those who are usually subject to scientific approach driven priorities. As more households plumb in rainwater tanks, collect and reuse reticulated supply, adopt different gardening regimes and other non-scientific approach sponsored solutions, scientific environmental knowledge's hold on the collective consciousness of ACT residents is being weakened. Space is now available for other environmental approaches to be embraced.

Hypercommodification

As water demand increases, stormwater is being remade from a waste product into an economic asset. This increase in economic value has been matched by an increase in the amount of money afforded to stormwater harvesting programs. As noted in Chapter One, as stormwater has been ascribed greater economic and social value, the willingness to invest capital in alternative, generally more technologically complex systems has increased. The range of technological approaches to stormwater harvesting beyond wetlands or WSUD are becoming more varied than the traditional low tech approaches of gutter and channel infrastructure. For example a detention/treatment system for harvesting stormwater from bridges in the Wet Tropics World Heritage Area of north Queensland, aims to use the harvested water for plants sheltered from rain by the bridges. Using zeoliths to treat the water, it is anticipated it will be of a very high quality (Hannah, pers. comm., 21/907). This increasing range of technological solutions reflects how the scientific approach, in spite of the challenges to it, clings to the tradition of technological and capitalist solutions.

This transformation of what was once an economic externality exposes this portion of overland flow to hypercommodification (Braun & Castree, 1998, p. 43), as nature becomes intensively mined as its extensive physical boundaries are met (Katz, 1998, p. 47). Following Katz, stormwater represents "extensive nature" (Katz, ibid) when water was perceived as abundant and some portions of no value. The repackaging of stormwater as a useful resource is an example of "intensive nature" (Katz, ibid); the 'waste' tag goes allowing stormwater to once again become overland flow and open to (hyper)commodification. Using wetlands, particularly constructed wetlands, in residential development, ostensibly to manage stormwater, is an example of hypercommodified overland flow, given the technological and capitalist investment and associated financial returns. The zeolite technology used in the Wet Tropics has been developed and marketed by private commercial interests. That is, the reframing of stormwater within the intensive/extensive nature dichotomy, is driven by capitalist incentives.

Given the intellectual, economic and climatically driven internal challenges to the stormwater construct and the varied and multiscale responses to the challenges, is it as Berkes says: resource crises are a "necessary" (1999, p. 160) part of environmental knowledge development. The changing understanding of stormwater presented in this research suggests Berkes may have a point. It has taken many dry years to force a committed reconsideration to the management of stormwater in the ACT. Thailand, on the other hand is transitioning from a time of local knowledge pre-eminence, where flooding was a normal, though occasionally problematic part, of the natural cycle, and always required for food and water security. Yet, as the scientific approach colonizes Thai nature and culture, Chonburi Province is becoming a flood vulnerable landscape, similarly to D'Souza's argued changes in Indian delta regions following British colonization and the imposition of the overland flow values and management practices of the scientific approach (2006, p. 215-216).

This examination of the challenges to, and changes in, both knowledge system's reinforces the awareness of the conceptual and physical overlaps between the two knowledge systems and geographies. It also shows how the conceptual overlaps are becoming greater as the scientific approach both colonizes Thai understandings of overland flow and questions itself, moving slowly toward multiple use and multiple value understandings of overland flow where non-controlled water environments can sometimes be acceptable.

Both knowledge systems appear to be changing markedly in their understandings and management of overland flow, similarly to evolutionary biology's punctuated equilibrium theory where "long periods of stability are punctuated with short periods of change" (Berkes, 1999, p. 161). Both the scientific and local environmental knowledge systems have been relatively stable (given knowledge systems are inherently fluid). However the nature of the recent challenges to both knowledge systems has created an opening for the possibility of a significant shift in understandings and practices. For local wisdom there is the chance to reclaim pride in its depth and versatility, allowing it to once again become an important part of the environmental knowledge framework in Thailand. Alternatively, the scientific approach has the opportunity to fundamentally reassess entrench values regarding overland flow that could see the displacement of stormwater with more sustainable water management constructs.

Conclusion: Policy Implications

As an adult, now understanding *why* the stormwater construct, I still find it foolish. I lament the loss of water's sacredness and non-economic values and the seemingly unquenchable desire to control is flows. This analysis of stormwater as a consequence of the features and values of the scientific approach, particularly the control and commodification of water environments, provides a more fulsome explanation than those of flooding and public health concerns. As one of a limited number of stormwater specific socio-cultural excavations of stormwater, it provides a more honest basis from which to modify, or reject, the current construct. A fuller picture of the stormwater construct gives room for creative, non-standard overland flow management practices.

Chapter One explored the scientific environmental knowledge understandings and management of overland flow, painting a picture of a generalist, transcontextual system inextricably linked to technology. Focussing largely on how the commodification of portions of overland flow, combined with a preference for controlled water environments, Chapter Two showed how the scientific approach constructed stormwater as a waste product. To further highlight the central influence of the key features of the scientific approach driving the stormwater construct, Chapter Three explored an alternative knowledge system, local environmental knowledge. By contrasting commodification with community economies and highlighting a willingness to work with uncontrolled water environments, local approaches were found to prefer multiple uses for, and have multiple values toward, overland flow. Thai local wisdom, presented in Chapter Four, provided a practical example of the way community economies and an acceptance of variable water environments can combine to make stormwater unlikely construct in local knowledge systems.

The case study investigated the application of the scientific approach and local knowledge in the ACT, Australia and Chonburi Province, Thailand. Providing a comparison of the two environmental knowledge systems through the wetlands focus, the case study also highlighted that both are currently under challenge. Chapter Five's analysis of the nature of the challenges to both systems found that the scientific approach is being challenged largely from within; local knowledge, as represented by local wisdom, is under challenge largely from external influences. A cross scale overview of the responses to these challenges indicated a geographical overlap between both knowledge systems, with the use of local approaches at the household and individual level evident in both the ACT and Chonburi. In spite of the conceptual overlaps between the knowledge systems, it is evident that the differences in economic practices and understandings regarding water environments strongly contribute to the presence, or otherwise, of a stormwater construct.

Following, in no particular order, are the major findings of this research.

Overland flow constructs are driven by the values embedded in applicable environmental knowledge system

Scientific environmental knowledge, driven largely by commodification of, and the desire to control, water environments creates stormwater. Local environmental knowledge is comfortable with communal approaches and works with variable water environments by adopting multiple use and multiple value approaches to overland flow.

Policy Implication: A deeper understanding of how knowledge systems influence overland flow constructs provides another avenue to manage natural resources so that are relevant to the place and time to which they are applied.

Physical and conceptual overlap between knowledge systems

These systems physically overlap, with elements of both knowledge systems overland flow understandings and practices found in both

Australian and Thai natural resource management practices. This becomes particularly evident at smaller scales, such as individual households where, for example, rainwater harvesting is common in both locations. The systems also have some conceptual overlap and share many process features such as an empirical focus, the tendency to classify and the use of data collected for natural resource management purposes.

Few values of the knowledge systems examined in this research are shared. However the reason for the existence of each knowledge system is the same: managing and allocating scarce resources equitably among a community, as defined by the socio-cultural priorities of that community.

Policy Implication: The areas of common ground between scientific and local environmental approaches can be used to assist the search for sustainable overland flow management practices.

Conceptual differences between knowledge systems

The significant conceptual differences between these knowledge systems revolve around differing economic approaches and water environment understandings contained in each system. The roles (and definitions) of experts in data collection and interpretation and the role of spirituality are just two important differences investigated in this research.

Policy Implication: The differences between knowledge systems require researchers from the scientific framework to give up the "questionable luxury of working solely within our [sic] traditions" (Ford & Martinez, 2000, p. 1250) when working in local approach communities. Similarly, local knowledge users need a stronger understanding of the values of the scientific approach to ensure a greater role in selecting which elements they wish to incorporate into their local systems.

Different understandings of water environments

The scientific approach prefers to control water in channels, natural or otherwise. Local approaches tend to incorporate the use of non-contained water environments, such as floods and temporary wetlands, into overland flow management practices.

Policy implication: Natural resource managers with a willingness to work with uncontrolled, unchannelled water flow are likely to achieve more widely accepted and sustainable outcomes, when working in local approach communities.

Different economic transactions dominate

The scientific approach operates within a capitalist commodification framework, whereas non-capitalist transactions dominate in communities where local approaches prevail. That is, the use of a community economy to incorporate a wide range of economic transactions in relation to natural resources in local approaches is contrasted to commodification as adopted by the scientific approach.

Policy Implications: Practitioners of the scientific approach need an awareness of the broad range of non-capitalist economic transactions so that they can be incorporated in water management policies.

Both environmental knowledge systems currently challenged

Although both environmental knowledge systems are currently being challenged, the nature of the challenges is different. Challenges to local knowledge overland flow management practices are primarily external, stemming from the colonizing nature of the scientific approach. Challenges to the scientific approach's stormwater construct are primarily internal, as the inefficiency of the construct becomes evident.

Policy Implication: This is an opportune time to influence policy understandings of overland flow from the waste focus of the scientific approach toward the multiple uses of local approaches.

Both knowledge systems are responding to challenge
The scientific approach responses to the challenges are split between a hypercommodification of stormwater and a move to more local approaches and understandings of overland flow.

For local wisdom, responses to these challenges range the continuum from embracing the scientific approach to community attempts to reject, or control, its introduction and use.

Policy Implication: That both knowledge systems are responding to epistemological challenges indicates that things can change, sometimes in unexpected ways, in response to accumulated evidence and experience.

Technological systems developed in one environment may not operate as experienced in a different environment
This research has demonstrated that conventional stormwater technology can not work in a tropical environment as it does in western European climates.

Policy Implication: It is important to learn from the failures of technologically conventional stormwater systems in Thailand. The use of climatically applicable management practices and technologies need to be investigated, rather than automatically applying standard scientific approaches.

The results of this research build on the previously limited understanding of the ways environmental knowledge systems influence the value and management of overland flow. What has been demonstrated is the potential of local environmental knowledge systems to offer diverse alternatives to managing overland flow beyond the pipe based, "clean water in, dirty water out" no-use paradigm of the scientific approach. Examining environmental knowledge systems with no similar waste water constructs can support reducing the scientific approach's reliance on unsustainable constructs such as stormwater. The unexpected finding that both knowledge systems are being challenged provides exciting opportunities and reveals the possibility of altering the current paradigm of "science is best" so that, as appropriate and feasible, the scientific approach can be used to support local approaches. At last, stormwater joins the other uses of overland flow in undergoing a socio-cultural critique of its use and management. The result is the clear, exciting suggestion that there are many positive outcomes possible from excavating the stormwater construct.

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